1889-90 & 1890-91

GENERAL REPORT

SURVEY OF INDIA

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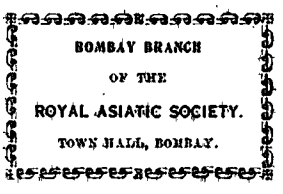

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FRONTISPIECE

Photo-etching. S.I.O. Calcutta, March '89.

IN THE WANGA VALLEY - HIMALAYAS

Reproduced on an orthochromatic plate from an oilpainting in black & white by Mrs Thuillier.

GENERAL REPORT

ON THE

OPERATIONS

OF THE

Survey of India Department

ADMINISTERED UNDER

THE GOVERNMENT OF INDIA

DURING

1889-90.

PREPARED UNDER THE DIRECTION OF

COLONEL H. R. THUILLIER, R.E.,
SURVEYOR-GENERAL OF INDIA.

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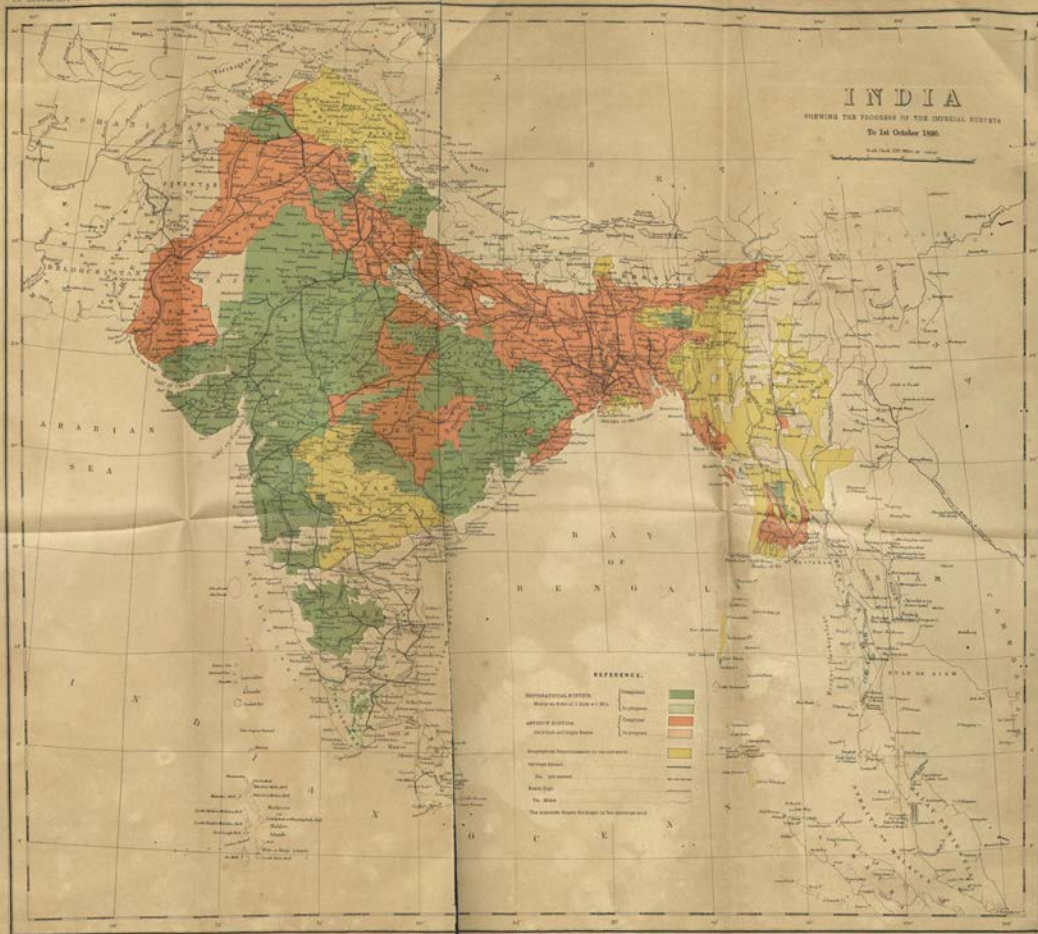
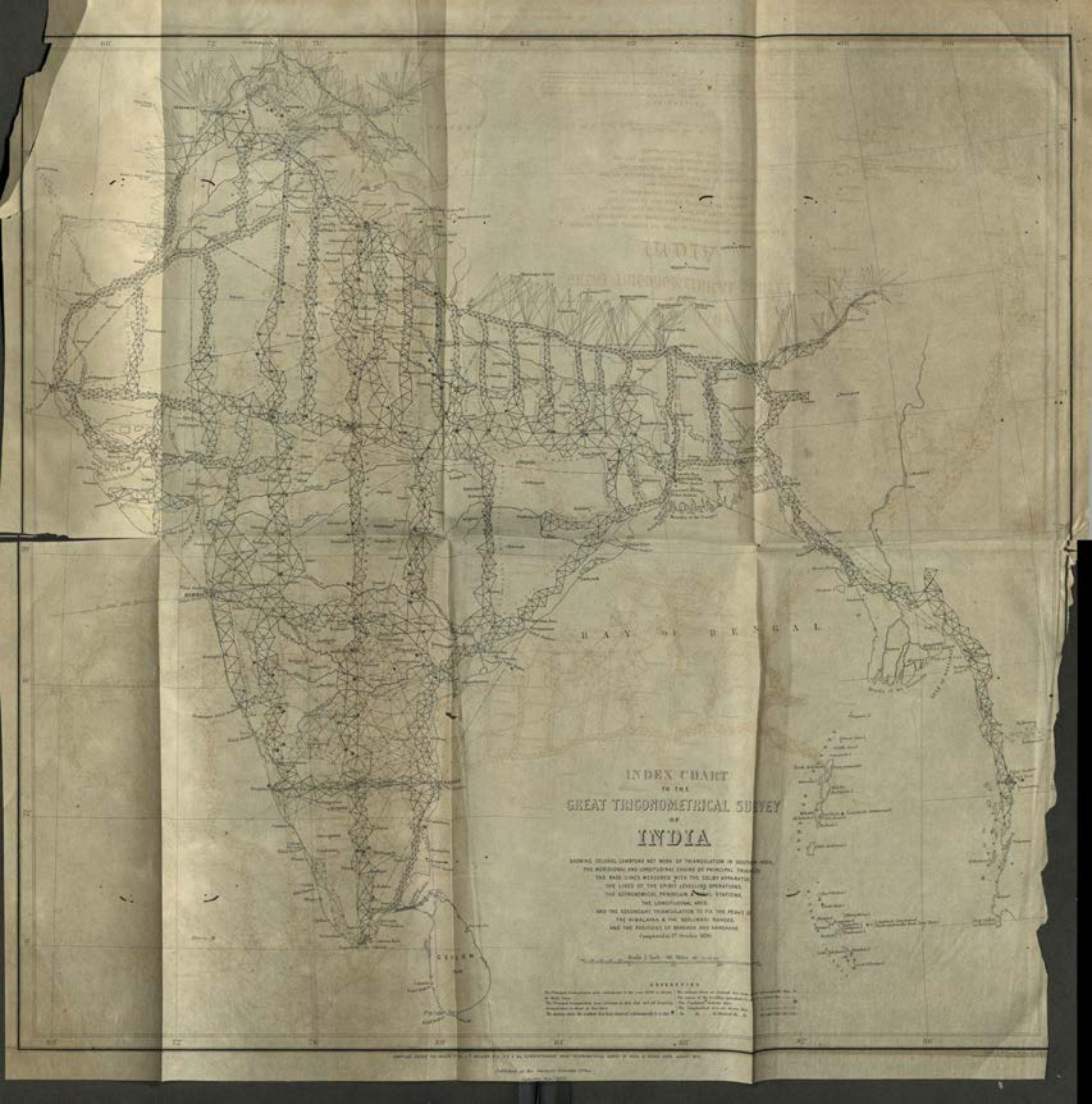

INDIA
SHEWING THE PROGRESS OF THE IMPERIAL SURVEYS
To 1st October 1880.
REFERENCE.
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN


INDEX CHART
TO THE
GREAT TRIGONOMETRICAL SURVEY
OF
INDIA
BAY OF BENGAL
CEYLON

GENERAL REPORT

ON THE

Operations of the Survey of India

DURING THE SURVEY YEAR

1889-90.

PART I.

SUMMARY.

1. The operations that are now reported on are for the survey year ending 30th September 1890.

2. The administration of the Department and the superintendence of the Topographical Branch have remained in the hands of Colonel H. R. Thuillier, R.E., throughout the year. Colonel J. Sconce, S.C., the Deputy Surveyor-General in charge of the Revenue Branch, proceeded on furlough on the 26th October 1889, when Lieutenant-Colonel C. Strahan, R.E., was appointed to officiate in that post, and he has held charge of it during the remainder of the year. The superintendence of the Trigonometrical Branch has been carried on by Colonel G. Strahan, R.E., who was confirmed in his appointment on the 12th October 1889.

3. The Cartographic and other offices at the Head-Quarters have been superintended, as usual, by three Assistant Surveyor-Generals. On the appointment of Colonel C. Strahan, R.E., to officiate as Deputy Surveyor-General, the charge of the Drawing and Engraving offices was assumed by Major St. G. C. Gore, R.E. The charge of the Photographic and Lithographic office was resumed by Colonel J. Waterhouse, S.C., on his return from privilege leave on the 5th December 1889. The Correspondence and Mathematical Instrument offices continued under the superintendence of Colonel M. W. Rogers, R.E., except for three months while he was absent on privilege leave, during which time Major Gore assumed charge of the Mathematical Instrument office, and Mr. T. Archdale Pope of the Correspondence office, in addition to their other duties.

4. The various field operations were carried on during the year by 24 parties and four small detachments; of these, four parties were engaged on topographical surveys, four on forest surveys, seven parties and one detachment on cadastral surveys, three parties on traverse surveys, four on scientific operations, and two parties and three detachments on geographical surveys. The whole of the operations are shown in the following tabular statement, grouped with reference to their nature and scope:—

Statement of Survey Operations and Parties.

Number of Party.	Nature and *locale* of operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
	Trigonometrical Survey.				
24	Burma	11	Mr. J. Eccles, M.A. . .	.....	D. S. G., Trig.
	Topographical Surveys.				
10	Bombay	12	Lieutenant-Colonel H. S. Hutchinson, S.C.	2" = 1 mile for reduction to half scale.	Ditto, Rev.
13	Mergui	13	Mr. A. D'Souza	1" = 1 mile for reproduction.	Ditto, ditto.

Statement of Survey Operations and Parties.

Number of Party.	Nature and *locale* of operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
15	Baluchistan	15	Lieutenant-Colonel T. H. Holdich, R.E.	2″ = 1 mile, 1″ = 1 mile, and ½″ = 1 mile for reproduction.	D. S. G., Topo.
18	Himalayas	18	Colonel H. C. B. Tanner, Bo. S.C.	4″ = 1 mile for reproduction and reduction to half scale; 2″ = 1 mile and 1″ = 1 mile for reproduction.	Ditto, Trig.
	Forest Surveys.				
14	Central Provinces	20	Colonel J. R. Wilmer, S.C.	4″ = 1 mile for reproduction.	Ditto, ditto.
17	Bombay	21	Colonel A. Pulhan, S.C.	16″ = 1 mile, 8″ = 1 mile, and 4″ = 1 mile for reproduction.	Ditto, Topo.
19	Madras	23	Lieutenant-Colonel J. R. McCullagh, R.E.	4″ = 1 mile for reproduction.	Ditto, ditto.
20	Burma	25	Colonel R. Beavan, S.C.	Ditto ditto	Ditto, ditto.
	Cadastral Surveys.				
2	Eastern Bengal	26	Colonel E. H. Steel, S.C. Mr. F. Grant.	16″ = 1 mile for reproduction.	Ditto, Rev.
3	Upper Burma	33	Mr. G. B. Scott	16″ = 1 mile, 2″ = 1 mile, and ½″ = 1 mile for reproduction.	Ditto, ditto.
4	Western Dooars	37	Colonel W. H. Wilkins, S.C. Mr. H. T. Hanby.	16″ = 1 mile for reproduction.	Ditto, ditto.
5	North-West Provinces	41	Lieutenant-Colonel J. E. Sandeman, S.C.	16″ = 1 mile 8″ = 1 mile, and 4″ = 1 mile for reproduction.	Ditto, ditto.
6	Assam	50	Mr. E. C. Barrett	16″ = 1 mile for reproduction.	Ditto, ditto.
7	Lower Burma	52	Mr. F. W. Kelly Mr. H. R. Littlemood.	Ditto ditto	Ditto, ditto.
8	Orissa	55	Mr. W. H. Patterson	16″ = 1 mile and 4″ = 1 mile for reproduction.	Ditto, ditto.
Det.	Burdwan Raj	62	Mr. T. Shaw	16″ = 1 mile for reproduction.	Ditto, ditto.
	Traverse Surveys.				
1	Punjab	64	Colonel D. Macdonald, S.C. Mr. J. S. Pemberton.	2″ = 1 mile, compilation for reduction to half scale.	Ditto, ditto.
9	Central Provinces	67	Mr. G. H. Cooke	16″ = 1 mile (skeleton plots).	Ditto, ditto.
12	Lower Burma	68	Mr. E. J. Jackson	Ditto ditto.	Ditto, ditto.
	Geodetic.				
22 & 23	Western India	70	Lieutenant S. G. Burrard, R.E. Lieutenant G. P. Lenox-Conyngham, R.E.	.....	Ditto, Trig.
	Tidal and Levelling operations.				
25	India	73	Mr. C. Wood Mr. G. Bolcham.	.....	Ditto, ditto.
	Geographical Surveys.				
11	Upper Burma	75	Captain H. M. Jackson, R.E. Lieutenant C. F. Close, R.E.	½″ = 1 mile	Ditto, Topo.
21	Upper Burma	76	Major J. R. Hobday, S.C.	Ditto ditto	Ditto, ditto.
Det.	Anglo-Siamese Boundary	78	Captain H. M. Jackson, R.E.	Ditto ditto	Ditto, ditto.
,,	Lushai Hills	79	Lieutenant W. J. Bythell, R.E.	Ditto ditto	Ditto, ditto.
,,	Chin Hills	81	Lieutenant T. F. B. Renny-Tailyour, R.E.	Ditto ditto	Ditto, ditto.

The total area that has been surveyed in detail during the year amounts to 1,17,871 square miles, and the traverse operations that have been carried out for the purpose of furnishing a basis for field surveys under Settlement Departments embrace an area of 6,796 square miles. The operations of the different parties are described in detail in Part II, in the order in which they appear in the above statement, and the following is a summary thereof:—

TRIGONOMETRICAL SURVEYS.

5. These operations have been confined, as in the previous year, to one party which was employed on continuing the principal triangulation for Upper Burma on the meridian of 96° 30′, and in proceeding with a part of the general scheme of the triangulation of the coasts of India and Burma to furnish points, consisting of artificial beacons as well as natural land-marks at convenient intervals, as a basis for future operations of the Marine Survey Department. The principal triangulation in Burma was extended along a meridional distance of 50 miles, covering an area of 1,205 square miles. For the Marine Survey Department, 35 points have been fixed along a distance of 170 miles from Kutabdia Light-house, off the coast of Chittagong, Bengal, to Akyab in Burma.

TOPOGRAPHICAL SURVEYS.

6. The number of parties employed on this class of surveys was increased at the commencement of the year from three to four, by the transfer of No. 13 Party, on the completion of the traverse operations upon which it had been engaged in the Central Provinces, to Mergui, for the purpose of making a topographical survey of the tin-bearing tracts in that district. The other three parties were employed as before, one in Bombay, one in Baluchistan, and one in the Himalayas, in continuation of the operations of the previous year.

7. In addition to the work of the regular topographical parties, various small areas were topographically surveyed by other parties, in connection with cadastral and forest operations, of intervening tracts not required for revenue purposes, in order to have complete topographical maps.

8. The compilation of new topographical maps of the plains of the Punjab on an accurate traverse basis has been continued by the traverse party employed there, the topography being obtained by reduction from the village maps prepared by the Settlement Department and subsequently tested in the field. A large area of country in the Ferozepore district was tested and mapped. In addition, the canals and adjoining topography in the Sikh states were re-surveyed on the 1-inch scale to enable new standard maps of those states to be prepared in conjunction with the old surveys of 1847-50.

9. The areas topographically surveyed on various scales during the year amount to 13,652 square miles, against 9,002 square miles in the previous year, by three parties. The total is made up as follows:—

5,263	square miles	surveyed	on the	½-inch	scale.
4,194	,,	,,	,,	1 ,,	,,
3,698	,,	,,	,,	2 ,,	,,
515	,,	,,	,,	4 ,,	,,
72	,,	,,	,,	6 ,,	,,

This out-turn is exclusive of the area of map compilation in the Punjab, referred to in the preceding paragraph, which amounted to 1,766 square miles on the 2-inch scale.

FOREST SURVEYS.

10. The four parties which were engaged on forest surveys during the preceding year in the Central Provinces, the Bombay and Madras Presidencies, and in Lower Burma, have continued their operations. In addition to these, forest surveys were made in the Jhansi and Kumaun districts by detachments of the cadastral survey party working in the North-West Provinces.

11. In the Central Provinces, the survey of the first and second class

reserves in the Hoshangabad and Betul districts was continued, but owing to the unhealthy climate of the tracts under survey, the field season is necessarily a short one, which prevents a large out-turn being accomplished. The classification of the forest growth and soils has been carried on as in the previous season.

12. In Bombay, the work done was principally in continuation of that carried on in the preceding season, *viz.*, surveys on the 8-inch scale of the forests in the North Kanara, Dharwar, Poona and South Kanara districts; and on the 4-inch scale in the North Kanara and Poona districts. Surveys were also made on the 16-inch scale of small areas in the Poona and Ahmednagar districts. Owing to the larger extents of country surveyed on the 8-inch scale, the total area completed is less than last year, but the out-turn accomplished is very satisfactory, considering that part of the operations were in malarious tracts. The larger scales have been adopted in accordance with the orders of the Bombay Government.

13. In Madras, the forest survey operations in the Madura, Tinnevelly and Salem districts were continued, and the out-turn of work, though not large, is satisfactory, considering the extremely difficult and unhealthy nature of the forest tracts under survey.

14. The party in Lower Burma continued the survey of reserved forests in the Prome and Toungoo districts on the 4-inch scale, and completed a small area on the same scale in the Thayetmyo district. Owing to an outbreak of cholera among the *khalásis* of the party while on their way to the field of operations, whereby the commencement of the work was delayed for a month, and to the season proving more than usually unhealthy, the out-turn of work is small, though as great as could be expected under the adverse circumstances.

15. In the North-West Provinces, a small area of forest land was surveyed in the Jhansi district on the 8-inch scale, and a larger area in the Kumaun district on the 4-inch scale, in connection with the cadastral surveys of those districts.

16. The total area of forest reserves surveyed during the year amounted to 1,646 square miles, as against 1,655 square miles executed last year by the same parties. The areas surveyed on the various scales are as follows:—

1,246	square miles	surveyed	on the	4-inch	scale.	
381	"	"	"	8	"	"
19	"	"	"	16	"	"

CADASTRAL SURVEYS.

17. Seven parties and one detachment have again this year been engaged on cadastral surveys. Three out of these seven parties and the detachment have been employed in Bengal, two in Burma, one in the North-Western Provinces and one in Assam.

(1) In Bengal, work was continued in the Western Dooars by the same party as last year; again they had to contend against exceptional difficulties, such as sickness, dense jungle and the impossibility of inducing the people of the country to render any efficient assistance. The work in this district is so unpopular amongst all the native employés that it is with great difficulty that men can be induced to go there at all. Desertions are common amongst the menials, and even amongst the surveyors themselves there have been several cases.

(2) The party, which last year was divided into several detachments and was scattered over different parts of Bengal, has been more concentrated and has been employed in Orissa, where the surveys of the estates of Kujang and Kanika were completed, and operations were commenced in the districts of Pooree and Cuttack. The field survey in Kujang and Kanika was carried out entirely by local agency at a contract rate of ₹16 per square mile; the cost of the chainmen attached to the local surveyors amounted to ₹30 to ₹40 per square mile in addition to this.

(3) The party, which during the last season was engaged on the survey of Bilaspur, was transferred to Eastern Bengal, where it commenced the survey of Serail in Tipperah and of part of the island of Dakhin Shahbazpur in Backer-

gunge. The detachment which was employed last year in Chittagong continued its work in that district, and was attached to this party. The surveyors in all these three localities met with the usual want of co-operation on the part of the inhabitants, which has been more or less the case wherever work has been carried on in Bengal; in addition to this, the enclosed nature of the country in Chittagong and the low, swampy nature of the country in Serail, tended to delay the work and make it more costly.

A detachment was also employed in Bengal on the cadastral survey of a portion of the Burdwan estate. The fact of the lands ordered for survey being much scattered, and the difficulty of ascertaining what lands were for survey and what were not, greatly added to the labours of the party.

(4) In Lower Burma, work was again carried on in the Thongwa district, where the same party completed 1,033 square miles, leaving about 316 to finish the district. The preliminary traverse of the Amherst district was commenced. There has been a further increase in the number of Burman surveyors employed in this party during the year, there having been 69 Burmans, against 44 Hindustani imported *amins;* the Burmans, however, only completed 419 square miles of survey, whilst the Hindustanis finished 614, or in other words, the Burman surveyor turns out an average of only $\frac{3}{7}$ths of the amount the Hindustani does. As the Burmans gain experience, they will no doubt more nearly approach the *amin* from India in quickness of working; but it is very doubtful if it will ever be cheaper to use the local agency, though there are other compensating advantages in doing so, notably that of training a considerable number of local men for revenue survey purposes in the future.

(5) The second Burma party was employed in the Kyaukse district, in the upper part of the Province. It was transferred from the Central Provinces where it had been engaged on traverse surveys, and re-organized for cadastral operations. This is the first cadastral survey that has been undertaken in Upper Burma. Two-thirds of the area of the level country was intersected by a network of small canals by means of which the country is constantly being inundated, rendering locomotion very difficult and survey work very arduous. Great sickness, too, at one time prostrated so many of the men as almost to stop work, but by dint of untiring energy on the part of Mr. G. B. Scott, and by keeping the men out in the field until the commencement of the monsoon, the cadastral survey of the district was completed. During the current season, operations will be commenced in the Mandalay district, where already some traversing has been executed, and in the Meiktila district, in which the royal lands are to be surveyed.

(6) The party employed in the North-Western Provinces was much sub-divided, and carried on work in several districts. One section continued and completed the cadastral survey and writing of records in the Jhansi district; this was executed entirely through the agency of the *patwáris*, or local village surveyors, under the complete control and supervision of the Survey Department. The work, which was under the superintendence of Colonel Sandeman has been carefully examined and checked, and has been pronounced to be thoroughly reliable and accurate; the cost rate per square mile is only ₹54 for the complete operations, *viz.*, traverse, field survey and record-of-rights: and the experiment may be said to have been a great success in every way, and much credit is due to Colonel Sandeman for the result. The same system was attempted in Garhwal, but totally failed there, principally owing to the opposition of the landholders, who were most inimical to the survey. In the State of Rampur, however, the *patwári* system was carried out successfully, though it is doubtful whether the whole tract will be completed without a little help from *amins*. Cadastral surveys were also completed almost entirely by the *patwáris* in Garhwal Bhábar, Kumaun Bhábar, and in the Terai district. The district of Lalitpur was traversed only. In Jhansi and Kumaun Bhábar the scattered district forest reserves were also topographically surveyed.

(7) The party engaged in Assam continued working in the same manner as heretofore; that is to say, with a mixture of imported and local agency, the latter being exclusively employed in the field-by-field survey, whilst the former did the survey of the grants of land. The work lay in the districts of Sibsagar and Nowgong, an area of 713 square miles having been cadastrally surveyed in the former and 143 square miles traversed in the latter district.

18. The areas that have been surveyed cadastrally in the different provinces are as follows:—

	Square miles.
Bengal	2,024
Burma	1,583
N.-W. Provinces	461
Assam	713
TOTAL	4,781

During 1888-89, the aggregate out-turn with the same number of parties was 4,836 square miles.

TRAVERSE SURVEYS.

19. The number of parties employed on this class of work has been reduced from six to three during the year under report, and they were engaged in the Punjab, Central Provinces and Burma.

20. The traverse operations in the plains of the Punjab, designed chiefly for the construction of a frame-work on which topographical maps are compiled in office by reduction from the village maps of the settlement surveys, has been continued to a limited extent to complete the traverse survey of the Gujarat district. The party was considerably reduced and has now been disbanded in accordance with the orders of the Government of India.

21. The traverse surveys in the Central Provinces which are designed to furnish a skeleton basis for settlement surveys by village *patwâris* are now approaching completion. The work has been continued during the year under report by one party in the districts of Chanda and Bhandara, which were both completed, and in the districts of Saugor, Balaghat and Betul, where certain small arrears remained. These have now been finished, and one district only is left to be done, Mandla, which will be undertaken during the current year.

22. One of the parties which had been employed last year in the Central Provinces was transferred to Burma for similar operations, with the object of traversing those portions of districts Prome, Hanthawaddy, Bassein, Tharawaddy and Henzada, which had been omitted when the cultivated portions of those districts were cadastrally surveyed some years ago. Work was commenced in the three first-named districts, but the progress was excessively slow in consequence of the extremely difficult nature of the country for traverse operations.

23. The total areas which have been traversed are as follows:—

	Square miles.
Punjab	1,687
Central Provinces	4,186
Burma	923
TOTAL	6,796

SPECIAL OPERATIONS.

24. The electro-telegraphic longitude operations which had again been temporarily suspended during the year previous to that under review, owing to the paucity of officers, were once more resumed. Seven arcs of longitude were measured between trigonometrical stations, in the Punjab, Baluchistan and Central India; and the longitude of Kalianpúr in Tonk, Central India, the adopted origin of the geodetic elements of the Great Trigonometrical Survey of India, was determined. It is now found that the value of the longitude of that station as accepted by Colonel Everest, and hitherto employed in the Great Trigonometrical Survey of India, is 2′-23·29″ too large. A new method of deducing the collimation constant, due to Captain Burrard's investigations, and which is of considerable importance and reflects great credit on its author, has this year been employed in the computations with excellent effect.

25. The tidal operations have been continued as usual; observations with the self-registering tide gauges were taken at seventeen stations in India,

Burma, Ceylon, and the Andaman Islands. Three observatories, *viz.*, Colombo, Galle, and Madras have been dismantled, the first two after having completed a six-year's registration, the last-named from the faulty character of the record it gave: it was considered undesirable to continue observations unless a more eligible spot for the observatory could be secured. Since then the Madras Government, by whom the expenses of the up-keep of the observatory have been defrayed, have decided to discontinue the tidal registrations. Sites for three new observatories have been selected, *viz.*, at Trincomallee, Minicoy, and Diamond Island at the mouth of the Bassein river in Burma. It has been decided to establish tidal observatories also at Jashk and Bushire in the Persian Gulf.

In connection with these operations, spirit-levelling operations were conducted from Hyderabad (Deccan) to Bezvada (in the Kistna district), and from Navánár (Navinál), near the head of the Gulf of Cutch, to Chilia near Tatta in Sind, giving a total out-turn of 462 miles of double levelling.

GEOGRAPHICAL SURVEYS AND RECONNAISSANCES.

26. Vast additions have been made to our geographical knowledge of the countries on the north-east and north-west borders of India; no less than 97,792 square miles, mostly of unknown country, having been brought under survey by this class of operation during the year under report.

27. The preliminary survey of Upper Burma has been continued by two field parties this year, under Major Hobday and Lieutenant Close, R.E., in connection partly with military and with exploring expeditions. Major Hobday and a sub-surveyor accompanied the force that was despatched against the Kachin tribes south of Bhamo and to the Momeit state, while another surveyor accompanied Lieutenant Daly, Superintendent of the Shan states, in his tour in the states of Northern Theinni, Thibaw and Taungbaing, whereby many gaps in our maps have been filled in. Lieutenant Close and Mr. Scott accompanied an exploring expedition to the Shan states of Baw, Yatzauk, &c., and Mr. F. Kitchen was attached to the Chinbôk expedition. Good progress has also been made with more regular surveys which are being undertaken district by district, and such operations were carried on in the districts of Myingyan, Meiktila, Pakokku, Katha, Shwebo, Sagaing and Lower Chindwin. The total area mapped by these parties in the above operations amounts to 18,912 square miles.

28. The Commission appointed to delimitate the boundary between Burma and Siam was accompanied by another survey party under Captain Jackson, R.E., which succeeded in mapping an area of 9,620 square miles of hitherto unknown country.

To the energetic guidance of Major Hobday and Captain Jackson, who have been engaged on the operations in Upper Burma since its annexation, these successful results are due. They have been ably supported by their assistants, among whom Messrs. Ogle and Kennedy are deserving of special mention.

29. The military operations in the Chin and Lushai hills afforded an opportunity for the acquisition of additional information regarding the geography of that unknown country which has been made the most of. Survey detachments under Lieutenants Renny-Tailyour and Bythell, R.E., accompanied the two columns, and they have secured an out-turn of 9,000 square miles of unexplored country, mapped on the $\frac{1}{4}$-inch scale; a result which is highly creditable to both these young officers. The triangulation, which was carried from the Chittagong and Burma sides respectively, was successfully connected in the neighbourhood of Haka.

30. The topographical party employed in Baluchistan has executed a large amount of geographical work, in addition to the regular survey of that country. Colonel Holdich and Lieutenant Mackenzie accompanied the expedition under Sir Robert Sandeman to the Zhob valley in December 1889, and surveyed an area of 4,500 square miles of new country on the $\frac{1}{4}$-inch scale. Similar surveys were effected in western Mekran and on the Perso-Baluch frontier by detachments under European assistants. The results comprised an area of 30,760 square miles of reconnaissance survey on the $\frac{1}{4}$-inch scale.

31. Assistant Surveyor Yusaf Sharif, K.B., who, as mentioned in paragraph 29 of last year's report, had been deputed to Persia on survey work in association with the Intelligence Branch of the Quarter Master General's Department,

during the summer of 1889, returned to India in October 1890, after having reconnoitred about 25,000 square miles of country on the $\frac{1}{8}$-inch scale.

32. The various operations mentioned above embrace for the most part ground now mapped for the first time, and the aggregate areas that have been thus geographically surveyed are as follows:—

25,000	square	miles	on the	$\frac{1}{8}$-inch scale.
72,442	"	"	"	$\frac{1}{4}$-inch "
350	"	"	"	$\frac{1}{2}$-inch "

HEAD QUARTERS OFFICES.

33. The work done in the various offices at Head-quarters is described in detail in Part III of this Report.

34. The number of new maps published during the year amounted to 4,701, of which 4,499 were cadastral maps. The total number of maps issued was 166,604, and their value ₹1,22,472. The cash sales of maps amounted to ₹11,552.

35. In the Drawing office, the general map of Burma, on the scale of 1 inch = 32 miles, commenced last year, has been completed and published. A second edition, with the hills printed in grey, is now in course of preparation, and will be published during the coming year. A third edition of the 32-mile map of India is in preparation, with extensions to the east and west, so as to include the limits of Burma and Baluchistan. The Railway map of India, on the 96-mile scale, which is being engraved on copper for the use of the Railway Department will be finally completed in May 1891.

36. The remarks in paragraph 36 of last year's annual Report, regarding the strain on the Drawing office, apply with even greater force this year: demands on every section continue to increase. The requirements of other departments for special maps employ most of the draftsmen's time, at the expense of the progress of the regular departmental work of the office; and the increasing pressure of work on this branch points to the early necessity of increasing the establishment.

37. The principal field work of the Calcutta City survey having been completed, the establishment engaged in the preparation of the fair maps was, for administrative convenience, placed under the supervision of the Assistant Surveyor-General in charge of the Drawing office.

The only field work done in connection with this survey during the year consisted in ascertaining and laying down the boundaries of registered holdings; the number laid down at the close of the year amounted to 17,401, of which 4,421 were added during the year under report: owing to the non-attendance of proprietors, very great delay is experienced in completing this part of the field work. Progress has been made in the preparation of the fair maps, but the work on them is delayed by the incompleteness of the boundaries above referred to.

38. In the Photographic and Lithographic office, the work done during the year shows a very large increase, especially in departmental publications. The total number of copies of maps and other subjects of all kinds printed off was 1,273,611, and their value was about ₹2,00,375, or ₹30,869 more than the out-turn of last year.

39. The new steam machinery was set up and commenced running in May 1890, though the large zincographic machine could not be utilized till July. It has been found to work well and without any difficulty, and has been an enormous help in getting through the large out-turn. The arrangements of the new office buildings have proved convenient and well adapted for the work, and the concentration of the various sections has greatly increased the efficiency of the establishment and rendered the supervision much more effective.

40. In the lithographic drawing and printing sections, the preparation of a third edition of the 32-mile map of India has been taken in hand and it is intended to extend the map westwards to longitude 58°E., and eastwards to longitude 104° E. A new edition of the plan of the City of Calcutta, on the 6-inch scale, was completed, but not printed off. Among the extra-departmental maps printed may be mentioned a forest map of India in 4 sheets on the scale of 48

miles = 1 inch; also ten more of the maps of country round cantonments, and a very large number of maps printed in colours to illustrate the Bengal administration reports.

41. The departmental maps photozincographed and published include a map of Burma and adjacent countries, with hills, on the 32-mile scale; second editions of the railway maps, on the 32, 48 and 64-mile scales; maps of districts Agra, Jaunpur, Bijnor and Ballia, on the 2-mile scale, prepared for the North-Western Provinces Government; besides 157 standard sheets of the topographical and revenue surveys on various scales. Among the large amount of extra-departmental work printed from zinc, the principal items are a new military map of India, showing the military districts and commands, on the 32-mile scale; also a large plan of the Port of Calcutta in 10 sheets. The new 24-mile map of Afghanistan with hills, in two colours, and railway maps on the 64 and 48-mile scales, with hills in grey, were completed and awaiting press order.

42. The heliogravure section has been steadily employed during the year, and some very good reproductions of difficult subjects have been turned out by it; the work is increasing, as the value of the process for reproducing all kinds of delicate drawings is becoming better known. A specimen of the process is given in the frontispiece to this Report, which has been taken, from an oil-painting in black and white, on an orthochromatic plate, so as to bring out the delicate bluish shades of the snows and distance. A series of 12 plates of drawings of the Archæological Survey of Western India were prepared for the Technical Art series. The amount of electrotyping has also increased.

No important changes have been made in any of the processes, but with improved facilities a considerable amount of experimental work in half-tone block printing has been done in the photo-transfer and heliogravure sections. Some experiments have been made with celluloid as a drawing and printing material, and Colonel Waterhouse has discovered an entirely new method of producing direct positive pictures on dry plates in the camera, with ordinary exposures, which seems likely to prove valuable when fully worked out.

It is very gratifying to record that Colonel Waterhouse's labours in, and services to photographic science and art, have attracted attention and have been appreciated in England. He has been awarded by the Photographic Society of Great Britain their Progress Medal for 1890 "on account of original and continuous researches in relation to orthochromatic photography; for his successful elaboration of a process of photographic etching, and for his recent investigations on the actions of thio-carbamides in the direct production of reversed images." Colonel Waterhouse may be justly congratulated on the distinction conferred.

43. There has been no diminution in the demands on the Mathematical Instrument office during the past year. The number of instruments issued on indent were 60,218, valued at ₹2,70,458, being an increase of nearly 3,000 in number, and ₹45,000 in value, over the issues of the previous year. There has been a continually increasing demand for instruments for railway surveys, and there is a steadily increasing issue for general purposes. During the year, 59,128 serviceable instruments, valued at ₹3,04,437, and 10,961 repairable instruments, valued at ₹69,127, were received into store.

44. In the Trigonometrical Branch office, Dehra Dun, the computing section has been engaged in passing through the press the volumes of the accounts of the Great Trigonometrical Survey. Volume XI, on astronomical latitudes, was completed and issued during the year, and volumes XII and XIII, containing the reduction of the principal triangulation of the Southern Trigon, have been since issued. Volume XIV, containing the south-west quadrilateral, is nearly ready for issue. The volumes containing accounts of the electro-telegraphic operations and of tidal operations are in progress. In the solar photographic section, photographs of the sun were taken on all days that the sun was visible, and the negatives sent to the Solar Physics Committee at South Kensington, as usual, for incorporation in the yearly volumes of the Greenwich observations.

45. The greater portion of the drawing and compiling section of the Trigonometrical Branch office, Dehra Dun, was removed to Simla in April 1890, in accordance with the orders of the Government of India, Revenue and Agricultural Department, in order that it might be associated with the Quarter Master General's Department for the purpose of preparing maps of the north-

west trans-frontier, and good progress has been made with the series of sheets appertaining thereto.

ESTABLISHMENT.

46. During the year, the future strength of the senior division of the department has been settled in conformity with the programme of operations that has been arranged, and it is hoped that the difficulty under which the department has been labouring for some years past of providing officers to superintend the various field operations, will be removed. The unusually large depletion of officers by retirement during the past and current years, amounting to nearly one-fifth of the whole establishment, will, however, prevent any immediate relief by the measure, as recruits require a considerable time to acquire the necessary experience to hold charge of field parties. Thus the operations of the year under report have been carried on with the same difficulty and anxiety that has prevailed for some years past.

47. During the year, the department has lost the services of four officers of the senior division, who have been associated with it for many years.

Colonel H. C. B. Tanner, S.C., was superannuated on the 31st October 1890, after a service of 28 years in the revenue and topographical branches.

Colonel E. H. Steel, S.C., died on the 14th November 1890 while on leave at Bellary. He had served for 24 years in the revenue branch of the department, in which he distinguished himself by his labours in placing cadastral surveys on an economical basis. His untimely death is a serious loss to the department.

Mr. F. W. Kelly retired on the 28th August, after a service of nearly 36 years. He was appointed originally to the junior division and promoted to the senior division in 1882, and served throughout in the revenue branch, in which he has rendered good service.

Mr. E. C. Ryall retired from the department on the 26th September 1890, after a service of 36 years. He was appointed originally to the junior division, in the trigonometrical branch, and was promoted to the senior division in 1873.

PART II.

THE OPERATIONS OF THE SEVERAL FIELD PARTIES.

TRIGONOMETRICAL SURVEYS.

PRINCIPAL AND SECONDARY TRIANGULATION.

BURMA.

NO. 24 PARTY.

48. This party, under Mr. Eccles, continued the principal triangulation in Burma northward for about 50 miles, along the meridian 96°30′ from the side Mya-ya-beng-kyo—Theyekhu, while a detachment fixed beacons for the Marine Department along the coast from Kutabdia Light-house, off the coast of Chittagong in Bengal, to Akyab in Burma.

Personnel.

Mr. J. Eccles, M.A., Officiating Deputy Superintendent, 4th grade, in charge.
Mr. T. H. Rendell, Surveyor, 3rd grade.
„ J. Hickie, do. 4th „
„ B. R. Hughes, Assistant Surveyor, 2nd grade.

49. The difficulties experienced in clearing the rays between the stations of the principal triangulation, owing to the dense nature of the jungle, became so great that it has been decided to incline the series some 30 miles to the eastward of its present meridian, so as to take advantage of the western peaks of the Karen hills.

50. During the earlier part of the season, the heavy state of the roads and jungle-tracks rendered progress somewhat slow, but in the end a very good season's work was obtained. Horizontal and vertical angles were taken at eight principal stations, and at two of them, circumpolar azimuths were observed.

51. The series was extended over a direct distance of 50 miles, embracing an area of 1,205 square miles. Six new principal stations were fixed and two were selected in advance.

52. The triangulation was executed with Troughton and Simms' new pattern 12-inch theodolite, No. A. 1888 or No. 1, and as far as can be judged from its performance, there is no reason to regret its employment. The chief difficulty experienced arose from the unsteadiness of the signals, and it is due to this cause that the average weight of the angles observed is comparatively low, *viz.*, 6·5.

53. The triangular errors, which give a much better idea of the value of the triangulation, compare well with those obtained in Burma with the 24-inch instrument, averaging 0·82″, against the latter's 0·73″.

54. During the recess, Mr. Eccles took a series of observations to determine the periodic errors in the graduation of the horizontal circle of the theodolite, and the conclusions which must be drawn from the results are that the graduation is excellent, and that the instrument is capable of giving work comparable with that obtained by the larger instruments previously employed.

55. The operations on the coast for fixing beacons for the Marine Department were placed under Mr. Rendell, who carried on this work along a distance of about 170 miles, in which 35 beacons, including 6 artificial structures, have been fixed in a satisfactory manner; further particulars regarding the work will be found in the narrative report of the operations at page iii of the appendix.

56. The health of the party during the season was excellent.*

*Mr. Eccles reports in favourable terms of all his assistants, *viz.*, Messrs. Rendell, Hickie and Hughes; especially of Mr. Hickie, who carried on the approximate work of the series.

TOPOGRAPHICAL SURVEYS.

GUJARAT AND SOUTHERN MARATHA COUNTRY, BOMBAY PRESIDENCY.

No. 10 Party.

57. This party, under the superintendence of Colonel H. S. Hutchinson, has continued topographical operations in Gujarat and the Southern Maratha country, Bombay Presidency. It was divided into two sections which left Poona for their respective operations during the latter half of November, 1889. The Gujarat section remained in the field till the end of June 1890, but the Southern Maratha section returned to Poona by the end of May. As the two sections worked entirely independently of one another, and the cost of their operations has been kept distinct, it will be convenient to describe the operations of each separately.

Personnel.

Colonel H. S. Hutchinson, S. C., Deputy Superintendent, 3rd grade, in charge.
Mr. W. Todd, Surveyor, 1st grade.
„ C Tapsell, Surveyor, 4th grade.
„ W. M. Kelly, Assistant Surveyor, 1st grade.
„ R. R. Dickenson, Assistant Surveyor, 1st grade.
„ G. A. Knight, Assistant Surveyor, 1st grade.
„ W. F. E. Adams, Assistant Surveyor, 3rd grade.
5 sub-surveyors and others.

Gujarat District Survey.

58. Messrs. Todd, Kelly and Knight, with 15 sub-surveyors, were deputed to carry on the topographical survey on the 2-inch scale in Gujarat, which was contained in sheets Nos. 179, 185 and 154. It had been originally intended to complete sheets Nos. 42, 57, 68 and 85, but in consequence of reports of scarcity in Rajputana and an application for the early survey of the Rajpipla state (which falls into sheets Nos. 185 and 186), it was decided to postpone the completion of these four sheets until 1890-91, when it is hoped that nothing will interfere with the filling up of this blank.

59. Sheet No. 179 had been commenced in the previous season, and as it was separated from the rest of the work, it was made over to Mr. Kelly with 7 sub-surveyors; he was made solely responsible for its completion, which was accomplished by the end of March, his men moving into sheets Nos. 185 and 186 as they completed their allotted portions. The ground in this sheet is intricate, being mostly covered with low hills, jungle and cultivation being much interlaced; there is very little of interest within the sheet unless the temple of Kalesri, near Bakor, be considered such. Its chief topographical feature is the Mahi river which runs through the sheet from east to west between steep and deep banks, some 150 feet below the general level of the country. This part of the country was visited by Colonel Hutchinson in February, and most of the sections examined *in situ*; each section was, on its completion, carefully examined by Mr. Kelly either with the plane-table or by linear *partal* wherever the country was open enough to admit of chain measurements; altogether 75 miles of check survey were thus measured.

60. Sheets Nos. 185, 186 and 154, which embrace most of the Rajpipla state and small portions of Baroda and Khandesh, were allotted to Mr. Todd, who was assisted by Mr. Knight. He commenced work with 8 sub-surveyors in sheet No. 185 on the 7th December and his detachment was strengthened towards the end of March by Mr. Kelly and his 7 sub-surveyors; but notwithstanding this large establishment, and every assistance from the local authorities, it was found impossible to complete these sheets, although the men were kept out in the field to the end of June when they were driven in by the commencement of the monsoon. Sheet No. 185, however, was completed, and most of No. 186, about 300 square miles only being left unfinished in the western half of sheet No. 186 and the eastern half of No. 154.

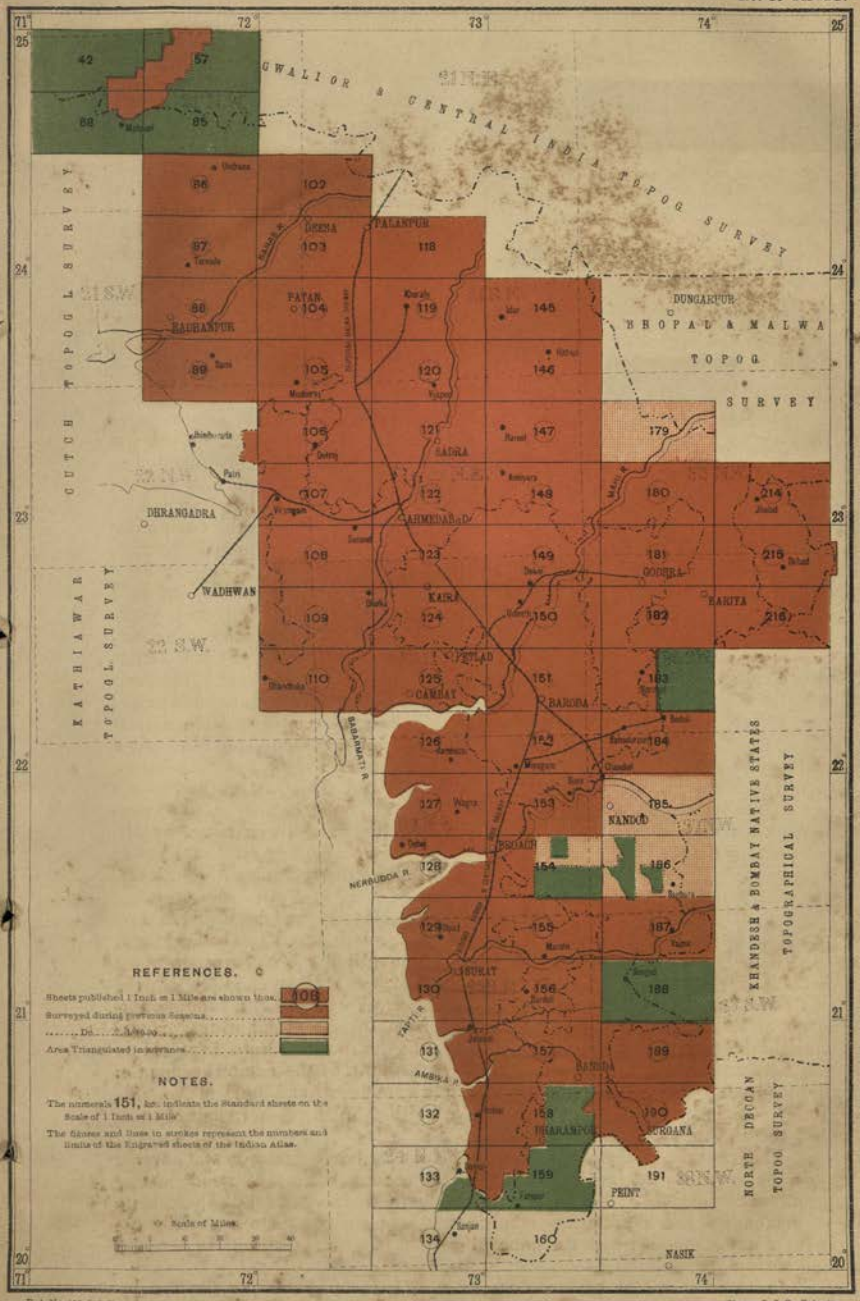
The country comprised in these sheets is mostly mountainous and covered with dense forest; the timber is insignificant though there is a good deal of small teak amongst it. The high grass jungle, the absence of roads, the paucity of inhabitants, and the difficulty of obtaining supplies and more especially the want of water, together with the unhealthiness of the climate, all tended to retard the survey.

61. A total area of 1,600 square miles was accomplished by the Gujarat

BOMBAY SURVEY.

INDEX TO THE TOPOGRAPHICAL SURVEY IN GUJARAT.

No. 10 PARTY.



REFERENCES.

Old Numbers on Sheets.	New Numbers on Index.
70	86
71	87
72	88
73	89
74	102
75	103
76	104
77	105
78	106
79	107
80	108
81	109
82	110
3	118
4	119
5	120
6	121
7	122
8	123
9	124
10	125
11	126
12	127
13	128
14	129
15	130
16	131
17	132
18	133
19	134
23	145
24	146
25	147
26	148
27	149
28	150
29	151
30	152
31	153
32	154
33	155
34	156
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36	158
37	159
38	160
39	179
40	180
41	181
42	182
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44	184
45	185
46	186
47	187
48	188
49	189
50	190
51	191
52	214
53	215
54	216

Nos. 68 & 85 are 43 & 85 of Rajputana Survey.

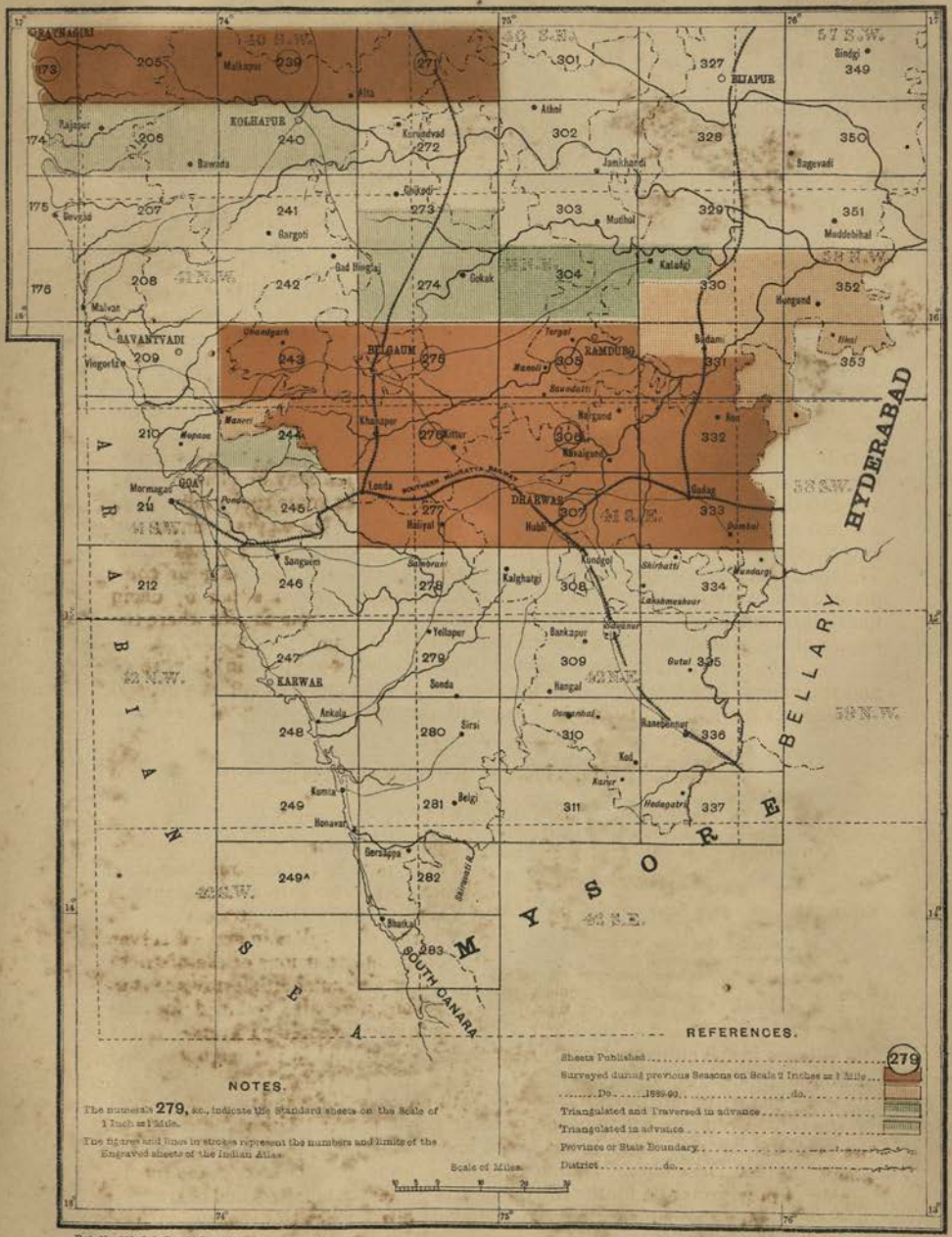
Reg. No. 403. 9 I. D.—24.01.—550.

Photo., S. I. O., Calcutta.

BOMBAY SURVEY.

INDEX TO THE TOPOGRAPHICAL SURVEY IN SOUTHERN MARATHA COUNTRY.

No. 10 PARTY.


GOA (NAGIRI)
KOLHAPUR
BELGAUM
DHARWAR
KARWAR
SAVANTVADI
BIJAPUR
BAGALKOT
RAMDURG
HYDERABAD
BELLARY
ARABIAN SEA
SOUTH CANARA
Malkapur
Ajra
Gargoti
Bawada
Gad Hinglaj
Gokak
Athni
Jamkhandi
Mudhol
Kaladgi
Badami
Hungund
Sindgi
Bagevadi
Muddebihal
Vingorla
Mapusa
Mormugao
Londa
Sangvem
Yellapur
Sonda
Ankola
Sirsi
Kumta
Honavar
Gersappa
Bhatkal
Hubli
Kalghatgi
Kundgol
Shirhatti
Wandargi
Lakshmeshwar
Bankapur
Gutal
Rangal
Ranebennur
Kod
Kurur
Hedagatti
Navalgund
Kaladgi
Bilgi
Mudhol
Jamkhandi
Bagalkot
Ilkal
Hungund
Badami
Gokak
Mundargi
Nargund
Ron
Kasalgund
Mansur
Khanapur
Hatkur
Bail Hongal
Sampgaon
Torgal
Bandalli
Manoli
Shirhatti
Lakshmeshwar
Kundgol
Kalghatgi
Hubli
Dharwar
Navalgund
Nargund
Ron
Kasalgund
Gokak
Mundargi
Bankapur
Gutal
Rangal
Ranebennur
Kod
Kurur
Hedagatti

section on the 2-inch scale, and considering all the difficulties of the country, this is considered satisfactory. All the work accomplished was well tested and proved good.

62. Sheets Nos. 179 and 185 have been finally mapped whilst Nos. 185 and 154 have been traced and the drawing completed as far as the survey has progressed.

Southern Maratha Survey.

63. Mr. Tapsell with Mr. Dickinson and Mr. Adams together with 8 sub-surveyors took the field on the 20th November for the purpose of continuing the topographical survey in the Southern Maratha country. Mr. Dickinson was told off to the triangulation and commenced work in sheet No. 330, and in succession completed Nos. 330, 304 and 274, as well as the southern half of sheet No. 273, equal to an area of 1,200 square miles, of which 820 square miles has yet to be traversed; this will be undertaken in due course during the coming field season. The mathematical results of this work are good, both as regards angular and linear errors. Mr. Tapsell, with Mr. Adams to assist him, carried on the 2-inch topographical and the traverse surveys; the detail work was commenced in sheet No. 331, and sheets Nos. 353A, 353, 352 and three-quarters of sheet No. 330, as well as a portion of sheet No. 244 were completed in succession; whilst the traverse work extended over the whole of Nos. 330 and 304, giving an area surveyed topographically of 1,372 square miles and a traversed area of 1,500 square miles.

64. The same system of survey was observed as hitherto; all the tri-junctions of villages being fixed by traverse or triangulation and the topographical details surveyed by plane-table, the whole being dotted over with heights determined by the aid of the clinometer. The ground surveyed may be characterised as generally speaking open and cultivated, but it includes some rocky hills thinly covered with scrub jungle. The portion, however, in sheet No. 244 is mountainous and densely forest-clad, and formed a most difficult and interesting bit of work. The final mapping of sheets Nos 331, 353A, 353, 352 and 244 has been completed, and every portion of this survey was thoroughly tested either by chain lines measured across or by examination with the plane-table *in situ* where the nature of the ground did not admit of the use of the chain.

65. The recess office was inspected by the Surveyor-General in July 1890, and the mapping and records were found to be in good progress and the general efficiency of the party to be in every way satisfactory.*

MERGUI DISTRICT, LOWER BURMA.

No. 13 Party.

66. This party, which for some years past has been engaged on traverse operations in the Central Provinces, was converted into a topographical survey party and transferred to Burma with orders to make a survey of the hilly portions of the district; a certain number of traverse surveyors were also retained for the purpose of running traverses round the villages in the cultivated tracts near the sea-coast, and in the neighbourhood of Mergui.

Personnel.

Mr. A. D'Souza, Deputy Superintendent, 4th grade, in charge.
„ H. E. T. Keelan, Surveyor, 1st grade.
„ A. J. Gibson, Surveyor, 2nd grade.
„ G. Vander Beek, Assistant Surveyor, 1st grade.
„ P. White, ditto ditto.
„ R. F. Warwick, ditto ditto.
15 sub-surveyors and others.

67. The party left Calcutta on the 29th October 1889 and reached Mergui on the 6th November, but the country being partly covered with water, owing to the rains not having ceased, it was found impossible to commence operations till about the 1st December. During this delay, arrangements were made for the supply of provisions and for the engagement of guides, interpreters and boats.

68. Under the supposition that the whole district was to be surveyed, field work was commenced in the northern portion, partly because of there being in that part a considerable area of cultivated ground which was to be traversed,

* Colonel Hutchinson reports favourably of all the European Assistants and especially selects Mr. C. Tapsell on account of his good management and work both in the field and in recess.

and partly on account of the proximity of the trigonometrical points from which the secondary triangulation could be started. As, however, it was found that the cost of a detailed topographical survey in such a terribly difficult country would be enormous, it was decided by the Government of India that the work should be discontinued after one season and that the party should be abolished. The Burma Government then directed that, in order to get as much useful work out of the party as possible during the limited time at their disposal, a 1-inch reconnaissance, rather than a rigidly accurate topographical survey, of the tin-mining tracts in the south should be made. A more accurate survey on a larger scale was asked for by Mr. Hughes of the Geological Survey, but this was vetoed on account of the extra expense and the want of time. The scene of operations was therefore shifted, and about the middle of February 1890, work was commenced in the tracts to the south, where it was known that tin existed or where mining operations had already been started.

69. In order that the work might be carried on as rapidly as possible, the usual procedure of fixing points for the detail surveyors by triangulation was abandoned, and the plane-tablers were directed to commence at once on points fixed by interpolation from such Great Trigonometrical Survey points as were available. This answered all practical purposes, for afterwards, when these points had been finally fixed by triangulation, it was found that the errors were very small and inappreciable on the scale.

70. The season's out-turn is as follows :—

Nature of work.	Area in square miles.
Boundary traverse	29
Topographical survey, 1-inch scale	442
Triangulation	871

In addition to this, 14,300 square miles in the neighbourhood of Mergui were cleared and prepared for triangulation; this, however, was abandoned when the programme was changed.

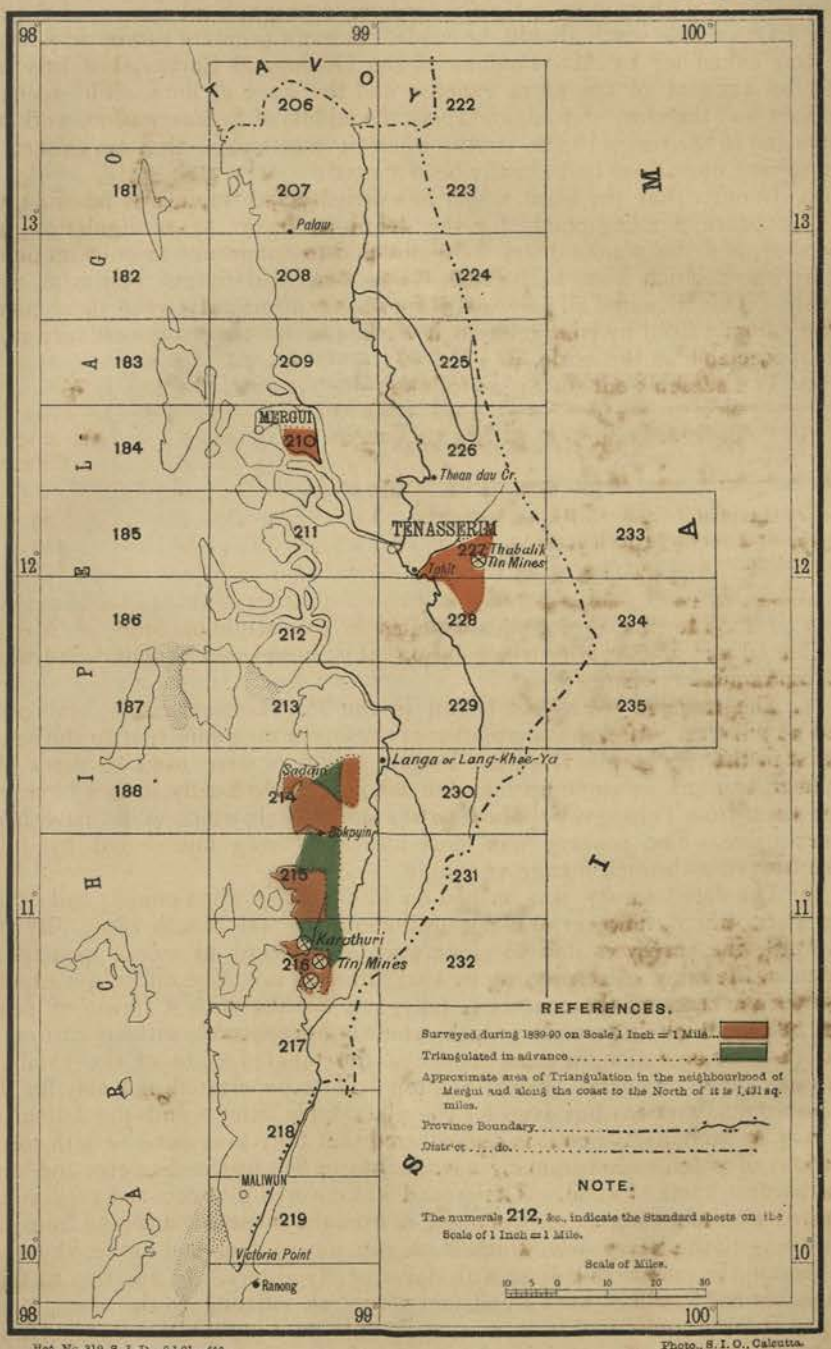
71. The traverse work was begun in the Pagoketoung circle, and comprised 28 villages. After the completion of these, the men were sent to the south to assist in the topographical work. Pottery cylinders were used to mark the permanent stations, as stone prisms were not procurable locally, and to have imported them from Penang would have cost a dollar each, which would have been too expensive. The country was most intricate, being intersected by tidal creeks fringed with thick mangrove jungle.

72. The detail survey was pushed on with energy when once it had made a fair start, which, however, was not until about the 1st March 1890. By the 30th April, the surveyors had to close work and return to recess quarters in Moulmein, the rainy season having by that time set in. The difficulties experienced were excessive; the country is hilly, and clothed with a forest of huge trees, below which is an undergrowth which is impenetrable without cutting, a most laborious operation, in consequence of the tangled state of the bamboo, cane, and other creepers. Every hill top had to be cleared, not only for the trigonometrical stations but even for the plane-table fixings, and the labour of this may be imagined when it is remembered that they were covered with trees, the stems of which varied from eighteen inches to five feet in diameter and were of the hardest kinds of wood. The ground was covered with decayed vegetation, saturated with moisture, either from rain or from the incessant dripping from the trees owing to the heavy dew, which made the air so foul and unhealthy that numbers of the men were laid up with fever or dysentery. In addition to this, the leeches and sandflies were a constant source of suffering to the men; none escaped these plagues, and in many cases men were incapacitated from work by the ulcers caused by their bites. A solution of phenyle was tried as a preventative, but it was quickly washed off and was of no use for any length of time. Bad as the inland tracts are, those on the sea-coast and along the banks of the large rivers are far worse, as they are absolutely inaccessible, owing to the fringe of mangrove swamps which extend all along them to a distance of 100 to 500 yards. Through this country there are scarcely any roads, and the very

BURMA SURVEY.

INDEX TO THE TOPOGRAPHICAL SURVEY IN DISTRICT MERGUI.

No. 13 PARTY.



Reg. No. 319, S. I. D.—8-1-91.—500.

Photo., S. I. O., Calcutta.

few that do exist are but little used by the villagers on account of the tigers, elephants and bears, which are very plentiful in these forests. The number of inhabitants is very small, and as they always build their houses on the banks of the creeks, they naturally use them as the readiest means of communication, and hence all the traffic is by boats. Carts and pack-bullocks are unknown. In such a country, the question of keeping all the detached camps supplied with provisions was a serious one and caused Mr. D'Souza a very great deal of anxiety, as any failure in forwarding supplies to any one of the camps might have resulted in serious consequences. The Mergui markets were found incapable of furnishing a continuous supply, and arrangements were made with the Agent of the British India Steam Navigation Company to bring from Rangoon what was necessary. Five depôts, which were supplied by boats from the central depôt at Mergui, were formed, and from these the provisions were distributed to the 14 detached camps. For the carriage of these supplies, elephants were tried but they proved to be of but little use, as the *mahouts* refused to let them carry more than what would be usually considered a bullock-load in India. Eventually arrangements were made for the hire of a steam launch, which greatly facilitated matters, and so far relieved Mr. D'Souza of one of his greatest anxieties, that he was enabled to attend more to his professional duties.

73. The triangulation, which was undertaken by Messrs. D'Souza and Keelan, was based on the Eastern Frontier Series of the Great Trigonometrical Survey. Luminous signals could very rarely be used, partly from the want of experienced signallers, but principally from the excessive difficulty in moving them about from one station to another and in keeping them supplied in such a country.

74. As it was impossible to complete in one season all that was desired by the Burma Government, the Government of India were asked to postpone the removal of the party and to allow it to remain another year; it being pointed out that there would be such a very small return for the heavy initial cost incurred during the first year. This was conceded, and instructions have been issued for the continuation of the 1-inch survey during 1890-91, after which it is finally decided that the party is to be abolished. Every endeavour will be made to complete the area required, about 1,400 square miles, but it would be unwise to guarantee it in a country beset with such difficulties.

75. Mr. D'Souza acknowledges his indebtedness to Colonel Alexander, the late Deputy Commissioner of Mergui, and to Mr. H. Batten, who succeeded him, for their courteous and ready assistance, as also to the Raja of Penang, for his kindness in placing two of his boats at his disposal.*

BALUCHISTAN.

NO. 15 PARTY.

76. Colonel Holdich continued to hold charge of this party, during the year, and the operations upon which it was engaged were similar to those of the preceding year, *viz.* :—

1. Triangulation.
2. Topography on the 2-inch scale.
3. Topography on the $\frac{1}{8}$-inch scale.
4. Geographical surveys on the $\frac{1}{4}$-inch and smaller scales.

Personnel.

Lieutenant-Colonel T. H. Holdich, R.E., Deputy Superintendent, 2nd grade, in charge.
Lieutenant R. J. H. Mackenzie, R.E., Assistant Superintendent, 1st grade.
Mr. T. E. M. Claudius, Surveyor, 3rd grade.
„ E. A. Wainwright, „ 4th „
„ W. C. G. Barckley, Assistant Surveyor, 1st grade, up to 16th December 1889.
„ E. Graham, Assistant Surveyor, 1st grade.
„ G. P. Tate, „ „ 1st grade.
Yusaf Sharif, Khan Bahadur, Assistant Surveyor, 3rd grade.
Hira Singh, Rai Bahadur, Assistant Surveyor, 3rd grade.

Sub-surveyors.

Imam Sharif K. B., Ahmad Ali, Abdul Gaffar, Hussein Baksh, Sheik Mohidin, Asghar Ali, Jaffar Ali, and Nasiruddin.

77. In order to cover the wide 7-scattered area which included the topographical survey of the season, the party was sub-divided into five sections, each section being under the immediate supervision of an European officer.

78. The first section consisted of a small survey party, including Colonel Holdich

* Mr. D'Souza speaks very highly of the services rendered by Messrs. A. J. Gibson, G. Vander Beek, P. White and R. F. Warwick; more especially does he mention Mr. Gibson, who had charge of the party during Mr. D'Souza's absence on leave. Of the native establishment, he brings to notice Hidayatulla, Koylash Chunder, Wajid Ali, and Boith Ram, as having done excellent work.

and Lieutenant Mackenzie, which accompanied Sir Robert Sandeman, K.C.S.I., in his expedition to the Zhob Valley in December 1889. Previous to the starting of the expedition, Lieutenant Mackenzie, accompanied by a soldier-surveyor, proceeded to the east of Toba in order to secure a base for fixing distant peaks to the north in Afghanistan. After taking observations on the peaks of Nigand and Kand, and effecting a valuable reconnaissance of the watershed between the Kadanai and Rod rivers, (the latter joining the Zhob near Kazhé) he rejoined the party by forced marches. The expedition, which had left Loralai on the 19th December, then proceeded to Morgha and crossed by a previously unexplored pass to the plains of Gosha. Thence, skirting the eastern slopes of the Babargarh mountains, the party turned westward into the Zhob Valley and camped at Apozai. On leaving Morgha, a sub-surveyor was detached to survey the watershed between that place and Gosha. Assistant surveyor Hira Singh took up the plane-tabling of the Gosha plains and the wild country eastward touching the Suliman range. During the halt of one month at Apozai, triangulation was extended, from the points fixed in previous years, northward and westward to the banks of the Kundar and Gomal: large scale surveys, specially adapted for railway purposes, were run of the line of the rivers between Mina and Apozai, and thence to a point beyond the junction of the Zhob and Sritoi rivers, and a geographical survey on the $\frac{1}{4}$-inch scale was made of all the country within reach. An expedition across the Chukhan or Sritoi drainage and through the mass of rugged limestone hills separating the Kundar from the Zhob added considerably to the geography. Lieutenant Mackenzie was enabled to reach one of the highest peaks, west of the Takht-i-Suliman, from which he overlooked the Upper Kundar and determined the general lie of the country westward. A special report by Colonel Holdich on the railway surveys has already been submitted to the Government. The expedition broke up on the 13th February, when Colonel Holdich proceeded to Dehra Dun to take charge of the Drawing office, and Lieutenant Mackenzie with the rest of the party returned to Quetta. In the operations above referred to, an area of about 4,500 square miles of new country was topographically surveyed.

79. The second section consisted of Mr. Claudius and a squad of soldier-surveyors. Mr. Claudius himself was engaged upon triangulation in Las Beyla for future extension of $\frac{1}{8}$-inch topography southward; his triangulation, which was based upon a side of the Great Indus Series, Great Trigonometrical Survey, covered an area of about 5,000 square miles, observations being taken from 19 stations. A junction was effected with the previous triangulation executed in Baluchistan in 1886-87, and the results proved to be satisfactory. The three soldier-surveyors attached to the section had been previously trained in the party in surveying, and had been again placed at the disposal of this department to assist in the general operations. They proved to be a very valuable addition to the working establishment, and were employed principally on $\frac{1}{8}$-inch topography, of which they completed an area of 1,324 square miles in continuation of previous work; in addition an area of nearly 2,000 square miles was surveyed on the $\frac{1}{4}$-inch scale.

80. The third section was under the charge of Mr. Barckley until the 16th December 1889. Before leaving, he had completed the survey of 310 square miles on the $\frac{1}{8}$-inch scale on the Toba plateau Mr. Wainwright then assumed charge of the section. His duties were (1) the supervision of the head-quarters office at Quetta; (2) the supervision of the field work of the sub-surveyors employed on 2-inch topography in the Pishin Valley and on $\frac{1}{2}$-inch topography in other parts, and (3) to complete the main series of triangles, which had been carried by Mr. McNair as far as Quetta, by an extension to the Khojak range. These duties were satisfactorily performed with the exception of the triangulation which was not successful, owing to climatic and other reasons which were sufficient to account for the failure. The observations have been condemned and will be done again next season with a 14-inch vernier theodolite, Mr. Wainwright being employed solely on this duty.

Of the sub-surveyors attached to this section, Imam Sharif was deputed to survey the northern slopes of the Toba plateau to the Kadanai river in connection with Mr. Barckley's survey of the plateau itself on the $\frac{1}{8}$-inch scale; he completed 975 square miles of excellent work in the face of considerable difficulties. The other sub-surveyors were employed on the $\frac{1}{8}$-inch surveys neces-

sary to complete the revision of former mapping; between them they succeeded in surveying an area of 2,654 square miles, completing the ½-inch revision work of the party. Their work is reported to be thoroughly satisfactory. A small area was also surveyed on the 2-inch scale, amounting to 118 square miles, which was thoroughly checked and the average of the work well kept up to the high standard of the previous work. This practically completes the 2-inch work required.

81. The fourth section consisted of Mr. E. Graham, one sub-surveyor and two soldier-surveyors, and was employed on triangulation and topography for ½-inch topography in Western Mekran. The surveyors experienced much opposition at the outset from the Mekranis. Work was commenced at Taptap hill, about 20 miles south-west of Panjgur, the nearest trigonometrical station to the area under survey. The topography, which extended to within 15 miles of Gwadar and eastwards as far as 64° east longitude, comprised 11,760 square miles on the ½-inch scale, all of which was examined and well reported on by Mr. Graham. The area triangulated by Mr. Graham amounted to 12,500 square miles and extended as far as Gwadar.

82. The fifth section, consisting of Mr. Tate and one sub-surveyor, was employed on triangulation and ½-inch topography on the Perso-Baluch frontier. A special report by Mr. Tate on the country operated in has already been submitted to the Foreign Department. He succeeded in triangulating 20,000 square miles and in topographically surveying 5,000 square miles, while a further area of 12,000 square miles of topography was executed by the sub-surveyor.

83. Detailed reports of the above operations and of the country surveyed have been separately prepared by the officers who were entrusted with the different works.

84. Assistant Surveyor Yusaf Sharif, Khan Bahadur, who had been deputed to accompany Colonel Sartorius, C.B., on Intelligence duty in Persia during the summer of 1889, and had not completed his tour at the close of the official year, returned to India in October. At a rough estimate he surveyed 25,000 square miles of country on the scale of 8 miles = 1 inch, which was completed without the advantage of trigonometrical basis. Colonel Holdich reports that Yusaf Sharif had to depend on his own resources, firstly, for occasional base measurements, and the triangulation of a few points at intervals; and, secondly, for check values on his position by means of astronomical observations for latitude and azimuth, in which he was helped by Colonel Sartorius. A comparison of his results with the best ascertained values of certain well-known places fixed by Colonel St. John and others, tends to prove the general accuracy of his work. In the absence of any connected scheme of triangulation, positive proof of the absolute accuracy of any single position is of course impossible, but the work, which was carried out under difficult conditions, may very safely be adopted as a basis for any future extension of work of a similar class. Colonel Holdich considers it to be as complete and as trustworthy as work of that nature can be made, and highly commends Yusaf Sharif for this further addition to the excellent services that have been previously rendered by him. A special report of his tour has been separately prepared by the Assistant Surveyor, which has already been submitted to the Foreign Department.

85. As regards the work of the soldier-surveyors, Colonel Holdich reports as follows:—

"It must, I think, be admitted that the army now possesses a very fine body of excellent topographers for frontier duty. I wish to record my opinion that many of these soldiers are now quite qualified to act as instructors in their own regiments, and I cannot but think that it would be much to the interest of Government that a proportion of them (especially those who have risen in their regiments and are thus disqualified by rank for ordinary field duty) should be supplied with the very simple plane-table equipment necessary to enable them to form classes of their own and thus utilize their knowledge by extending it, after they have themselves retired from the regular routine. They should effect their own triangulation with the plane-table and not be supplied with data of any sort. I need hardly say that officers as well as men could learn a great deal in this way."

86. Regarding the work of the recess season, Colonel Holdich reports as follows:—

"At present I am not in a position to report on the recess out-turn of mapping, no maps having been finally completed. The whole series of 2-inch maps comprising eight or ten sheets is, however, very nearly complete, and two sets of the ½-inch sheets are in hand. All computations are complete and a very large amount of route information has

been compiled for the Intelligence Branch, Quarter Master General's Department, in addition to the special and preliminary maps prepared for the railway authorities and Zhob expedition.

87. The total out-turn of field work for the season is as follows:—

Triangulation	37,500 Sq. miles.
Topographical survey, 2-inch scale . . .	118 " "
" " ½ " " . . .	5,263 " "
" " ¼ " " . . .	35,260 " "
" " ⅛ " " . . .	25,000 " "

88. The above record is highly creditable to Colonel Holdich's energetic superintendence and to the exertions of his assistants, who, in carrying out the operations in Baluchistan, have been necessarily placed in positions of independent responsibility under difficult conditions requiring tact, energy and resolution, the possession of which qualities they have fully exemplified*.

HIMALAYAS, PUNJAB.

No. 18 Party.

89. This party, which continued under the superintendence of Colonel Tanner, took the field in November 1889, and carried on field operations till July 1890, when it returned to recess quarters at Simlâ, leaving one detachment to continue the triangulation in the higher regions of Lahoul, where the stations of observation ranged from 12,500 to 19,400 feet above sea-level.

Personnel.

Colonel H. C. B. Tanner, S.C., Offg. Deputy Superintendent, 1st grade, in charge.
Mr. C. D. Potter, Surveyor, 1st grade.
" W. Robert, Assistant Surveyor, 1st grade.
" W. A. Fielding, do. do., 1st do.
" P. F. Prunty, do. do., 1st do.
" R. W. Senior, do. do., 1st do.

Sub-Surveyors.

Shah Nasiruddin, Atwa Singh, Wahid Ali Khan, Ram Saran, Shempa, Nima Sing, and 15 others.

90. The party was engaged on the several operations, the nature and scope of which were described in paragraphs 75 and 76 of Part II of the Annual Report for last year, and for ready reference are again given below:—

(1) A topographical survey of the Kangra district, the hill portions of the Umballa and Gurdaspur districts, and of the hill states about Simla, including both British and feudatory tracts. The scale for the former, except in very high, mountainous regions, is 4 inches =1 mile; that for the feudatory states is 2 inches=1 mile, while the high, mountainous regions, both British and feudatory, are surveyed on the 1-inch scale.

(2) Traverse operations to fix the tri-junctions of *mauza* and *tikka* boundaries and other permanent objects, so as to afford a suitable basis for the construction of the settlement maps of the British districts by local agency.

(3) The preparation of plots of the above traverse points intended for use as *patwári* field maps.

(4) The survey of forest boundaries.

(5) The drawing of the fair topographical maps.

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* Regarding the work done by the various assistants with the party, Colonel Holdich reports as follows:—

"I need only mention the aptitude for geographical triangulation and the energy shown by Lieutenant Mackenzie, who is rapidly becoming an experienced and accurate trans-frontier surveyor.

"I have to record my satisfaction with the results of Mr. Claudius's triangulation, and considering that his work was carried out in face of constant difficulties attendant on the destruction of his cairns and stations, I consider the result very creditable indeed.

"It says much for Mr. Wainwright's good management, as also for the writer's (Hira Lal's) ability, that the head-quarters duties were so satisfactorily performed.

"Mr. Graham has, before this season, proved himself to be possessed of just those qualities which are required for a successful trans-frontier surveyor. His energy, pluck, and readiness of resource have helped him out of all difficulties during this most particularly trying season in a country that is generally either desert or hostile.

"Mr. Tate has also conducted a trying reconnaissance to a successful conclusion, and his services have met with recognition from the Political authorities.

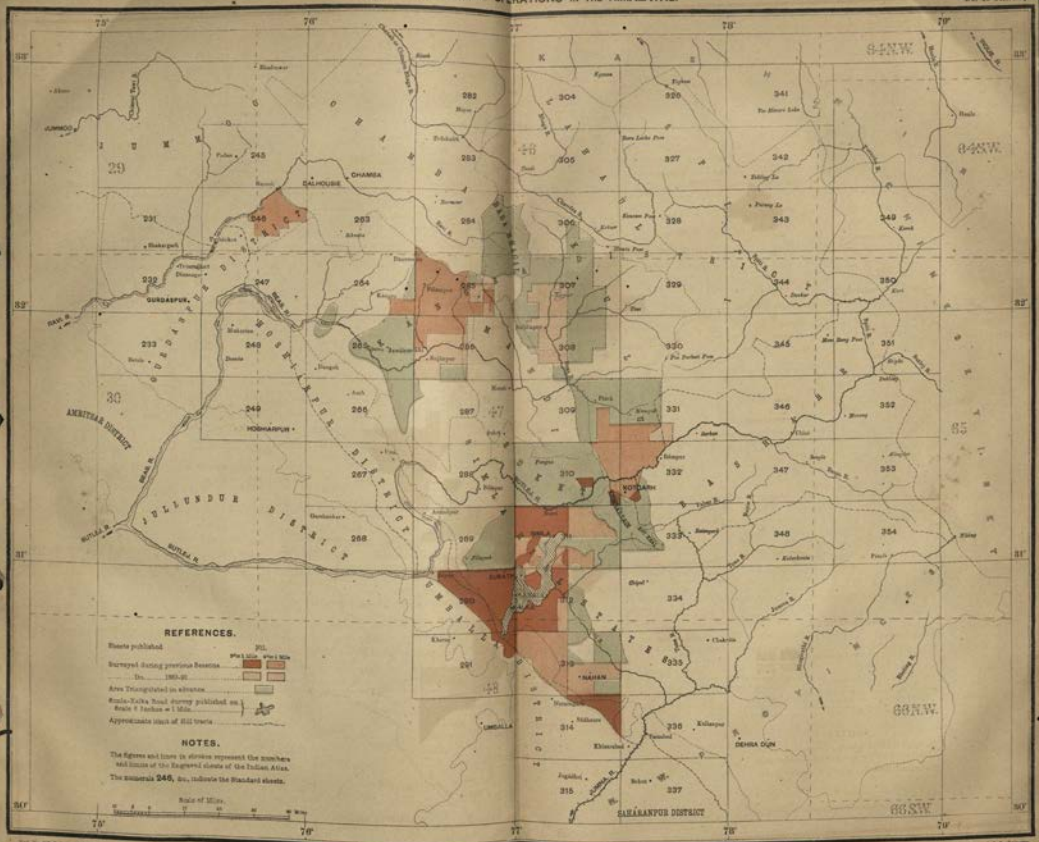
"Rai Hira Singh's performances have already been specially brought to your notice in a complimentary letter by the Quarter Master General.

"Of the sub-surveyors, Imam Sharif's excellent services have so often been brought to notice that it is almost superfluous to call attention to them again. Sub-surveyors Hussein Baksh, Asghar Ali, and Jaffar Ali are all thoroughly trustworthy men and experienced surveyors and were specially selected for independent work."

PUNJAB SURVEY.

INDEX TO THE SURVEY OPERATIONS IN THE HIMALAYAS.

No. 13 PART.



91. The areas which have been topographically surveyed in the different localities are as follows:—

Locality.	Scale.	Area; square miles.	Remarks.
District Kángra . .	4 inches=1 mile	402	
Simla Hill States . .	2 „ =1 „	364	Including 63 square miles of forest blocks.
Total .	.....	766	

The survey of Kalka, on the scale of 48 inches=1 mile, was commenced on the requisition of the Deputy Commissioner of Simla, but when only 0·17 square miles was completed, the work was stopped for want of funds, and is in abeyance.

92. The triangulation for 4-inch topography has been extended over 116 square miles, that for 2-inch work over 80 square miles, and for the 1-inch work over 600 square miles.

93. The traverse work embraced an area of 47 square miles, and was plotted on the scale of 27·547 inches=1 mile, on 531 sheets, prepared to serve as a frame-work for the field by field survey to be undertaken by *patwáris* under the Settlement Department. These sheets have been made over to the Deputy Commissioner of Kángra; this completes the skeleton plots required for this purpose. Besides the above, 178 sheets, each comprising a whole *mauza* or *tikka*, have been plotted on the scale of 56·57 inches=1 mile and furnished to the Assistant Commissioner of Kullu.

94. For the Forest Department, 74 blocks in all have been surveyed in the Kángra district and 12 blocks in the Gurdaspur district. In Kullu, 170 blocks have been specially demarcated with distinguishing boundary-marks and mapped. In the Simla Hill States, 175 blocks have been surveyed on the 2-inch scale, of which 30 were taken up and completed during the year under report; these blocks have been demarcated with distinguishing pillars at the salient angles. The forest blocks in the Simla Hill States have been surveyed on the 2-inch scale, but at the special request of the Deputy Commissioner of Simla it has been arranged to re-survey them in skeleton on double that scale.

95. The cost-rates, as given in the summary on page 84 show again on the whole a considerable reduction as compared with those of previous years.

96. The instruction of native soldiers in surveying has continued to form one of the duties of this party. Three men have completed their course of training and returned to their regiments, while one continues with the party, and three new men have lately been attached to it for instruction.

97. The British tracts have been surveyed on the 4-inch scale in localities which are either mountainous or hilly, and, except in the small strip along the Beás Valley, never flat. The 2-inch survey has been carried on in hilly regions in Native States, and partly in the difficult slopes along the Sutlej river, where the ridges are exceedingly steep and the valleys much confined.

98. Nineteen cases of disputed boundaries were brought to notice in the Simla Hill States, and the Deputy Commissioner has arranged to have them enquired into during the ensuing field season. Many of the cases referred to are trivial, and can be settled without any trouble, but some are of graver importance. The landholders have probably thought the presence of the survey party to be a favourable opportunity of putting forward claims for the land of their neighbours that may have been settled in years past.

99. Some parts of the country which have to be surveyed on the 4-inch scale are perhaps the most difficult that could be undertaken. In some of the side valleys between Plach and Bajaura, steep jungle-clad slopes rise precipitously from the very banks of confined torrents, and literally no place seems available on which to set up the plane-table. The Tirtan Valley, visited by Colonel Tanner in June 1890, is typical of the rest. In three days' march up this valley he had to make six bridges over the torrent, and from no single position were the ridges on either side visible, and this fact points to the impediments

that the plane-tabler will have to encounter. The valuable forests which lie in these valleys demand a fairly accurate survey of their boundaries, so the 4-inch work will have to be carried on, whatever the difficulties of the work may be.

100. During last autumn, a detachment of this party under Mr. Robert, accompanied by Sub-surveyor Wahid Ali, visited some stations of the Cherrapoonjee and Sylhet series, and observed to about 200 points in the Bhutan hills from one of them; from a second station, about 20 points were observed; but after securing these, clouds and haze set in and completely stopped observations to the Bhutan peaks. Sub-surveyor Wahid Ali has again been sent to extend the observations from stations to the eastward of Somullon and Dinghei hill stations, and it is hoped that he may add considerably to the number of fixed peaks in Bhutan. It will take some season's observations before it can be hoped to secure most of the prominent peaks in Bhutan owing to the almost constant prevalence of haze or cloud.

101. During the past two months the computation of Colonel Tanner's triangulation in Western Nepal has been resumed, and nearly all has been computed so far as the triangles are concerned. Some progress has been made in the computations of heights, and now the triangulation done by Sub-surveyor Rinzin in Western Nepal is being computed, and appears to be coming out well.*

FOREST SURVEYS.

CENTRAL PROVINCES.

No. 14 Party.

102. This party has been employed in continuation of the previous year's work on the survey of forest reserves in the Hoshangabad and Betul districts. The strength of the party on taking the field is shown in the margin.

Personnel.

Colonel J. R. Wilmer, S.C., Offg. Deputy Superintendent, 2nd grade, in charge.
Mr. A. Christie, Surveyor, 3rd grade.
„ J. Keating, Assistant Surveyor, 1st grade.
„ D. Campbell, do. do. 1st do.
„ F. E. Warde, do. do. 2nd do.
„ H. G. Shaw, do. do. 3rd do.

Sub-surveyors.

Azim Khan, Prem Raj, Mahomed Zakaria, Gurdutt Singh, Hyder Ali, and 12 others, and 30 temporary sub-surveyors and computers.

103. The survey is on the scale of 4 inches to a mile, and embraces first and second class reserves, including protected and unprotected areas, but omits all *málguzári* lands.

104. Detail survey was carried on in the southern portion of the Kalibhit forest of district Hoshangabad, which is now completed, and in the Khamapur forest of district Betul; a very small portion remains unsurveyed to complete the latter forest. The triangulation was as usual run in advance of topography in the Sáonligarh and Bowergarh forest reserves, extending also to a portion of the second class forests in sheets Nos. 23, 24 and 25. The eastern portion of the Khamapur forest was also triangulated in the season under report, but the triangulation was computed in the field and the area was also surveyed in detail. The forest boundaries and fire lines, as well as the principal roads and foot-paths in the ground that was triangulated were traversed by theodolite and chain to give more fixed points for the plane-tablers. The boundaries of eight detached forest blocks were also traversed.

105. The out-turn of the season's work was as follows:—

1. Triangulation of 661 square miles, fixing 687 points (including stations) and 663 heights.
2. Detail survey, on the 4-inch scale, of 405 square miles.
3. Traversing of 506 linear miles.
4. The classification of forest growth and soils of the whole area surveyed in detail.

106. The detail survey was rigorously tested by the European assistants, who were constantly moving about and daily checking the work of the sub-surveyors under their respective charges, and also by the officer in charge of

* Colonel Tanner reports very favourably of all his European assistants, and brings to notice that they have given entire satisfaction. Sub-surveyor Ram Saran and several others have also been well reported on.

CENTRAL PROVINCES SURVEY.

INDEX TO THE FOREST SURVEYS IN DISTRICTS HOSHANGABAD AND BETUL.

No. 14 PARTY.

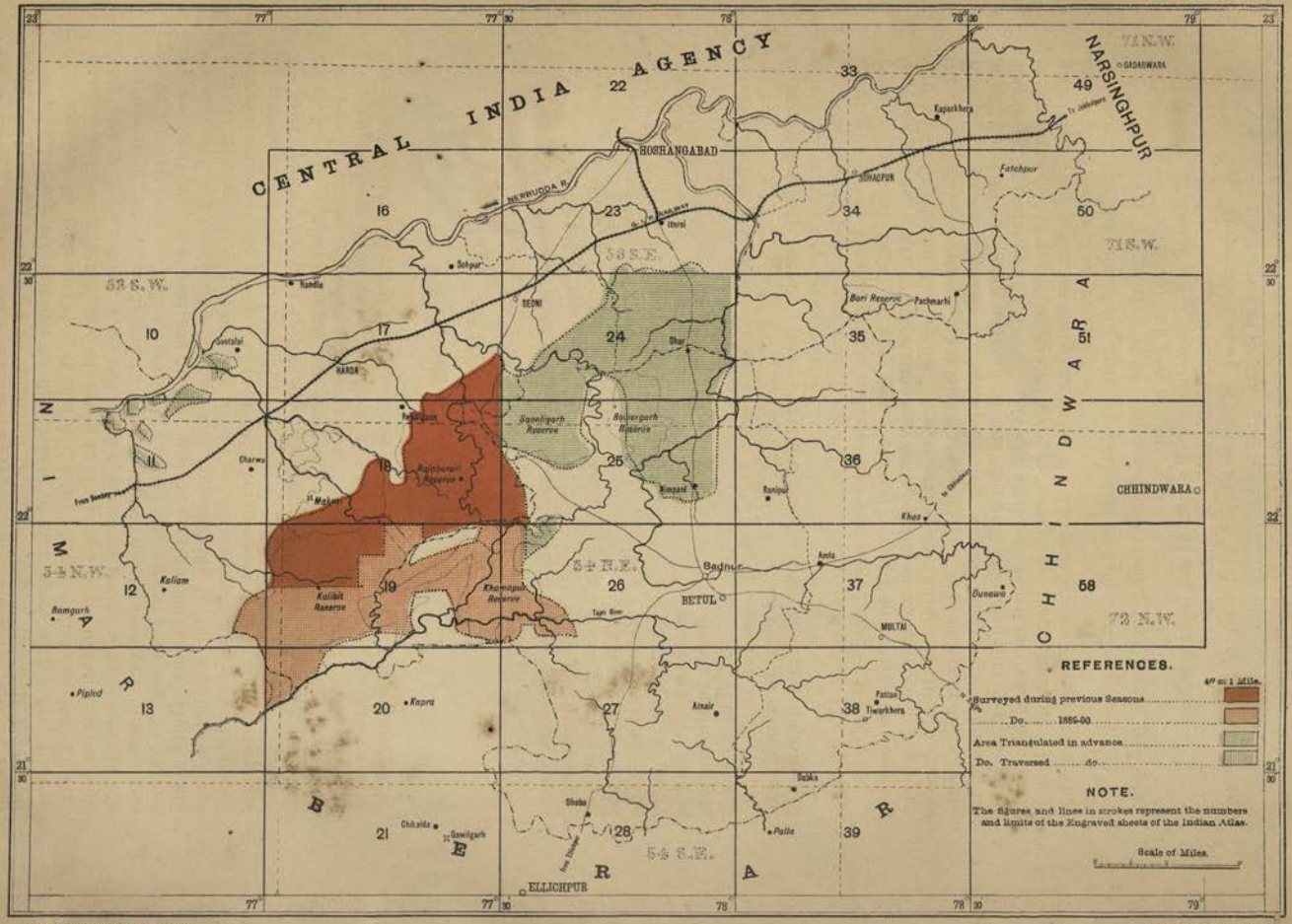


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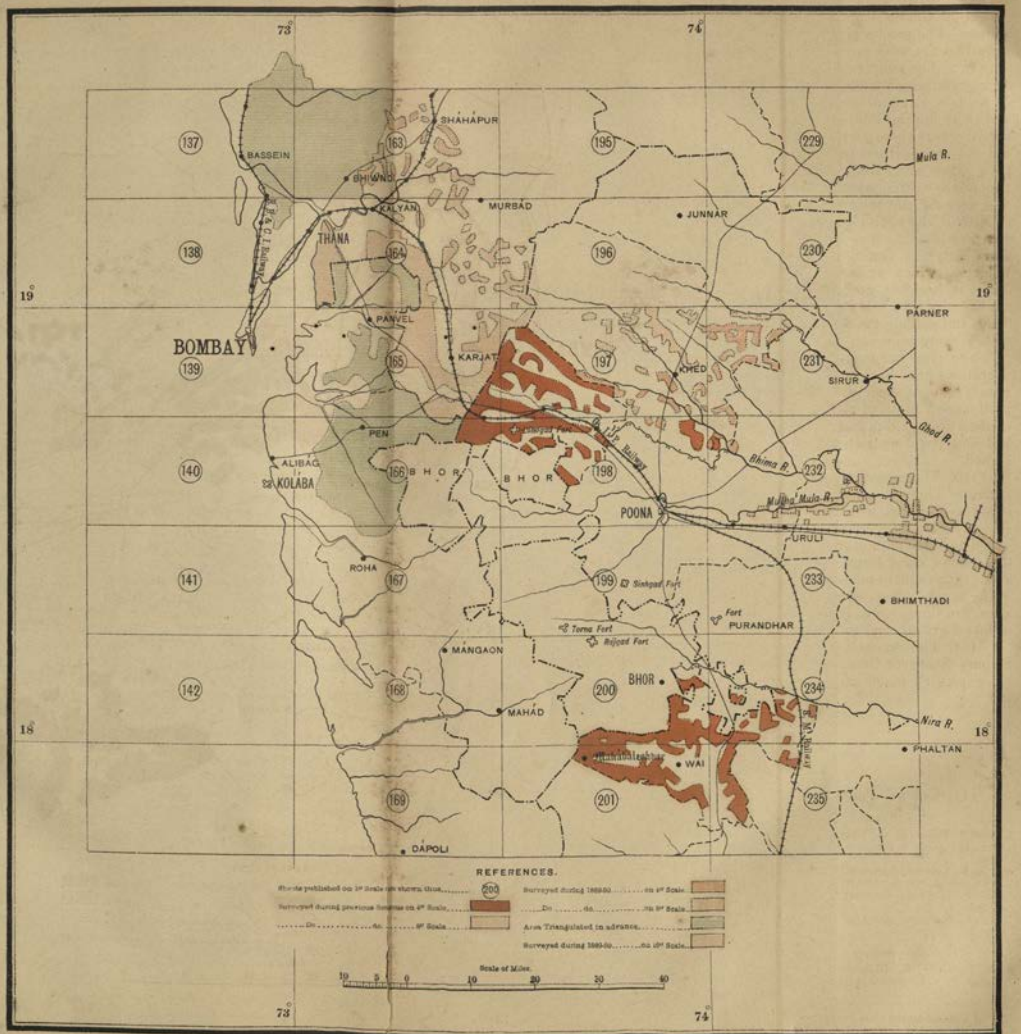
Photo., S. I. O., Calcutta.

BOMBAY SURVEY.

INDEX TO THE FOREST SURVEYS IN PORTION OF THE NORTHERN CIRCLE.

No. 17 PARTY.



Reg. No. 351, S. I. D.—8-1-01.—351.

Photo., S. I. O., Calcutta.

the party. The work proved to be accurately done, with few exceptions in the case of one or two temporary sub-surveyors, whose contouring had to be rectified a little. The results of the computations of the triangulation and traverses also show that the work is creditable to those concerned.

107. The country surveyed was very hilly and covered with jungle and high grass, which made the survey operations tedious and slow. There were no roads or rivers of any importance except the Tapti, which was met with here and there flowing from east to west. It has a rocky bottom and can be crossed almost everywhere; but its waters are not wholesome, as those who drank it did not escape from fever: even the local inhabitants on the banks preferred taking their water from some inland well, rather than from the river. The water-supply was scarce, especially after the first week of April. The local labour was also very difficult to obtain at that time.

108. The health of the party was generally the same as last year. The cases of fever, although very numerous, were not, except in a few instances, of a severe type. During the latter part of April, the fever took more the form of influenza, which was then very prevalent in the villages, and few men escaped. There is, however, no doubt that the precautions taken to prevent sickness, *viz.*, the issue of blankets to the menials, the distribution of tea and quinine pills daily, and making the men drink boiled and filtered water, had a great deal to do with keeping off fever.

109. The fair mapping and chart of the triangulation of the field season's operations have been completed, and comprise 21 standard-sized sections on the 4-inch scale in sheets Nos. 12, 13, 19, 20 and 26, which have been drawn for reproduction. Maps of classification of forests and soils, prepared according to the method described in last year's report, of all the published sheets of Hoshangabad and Betul districts, have been drawn and sent to the forest officers concerned.

110. Three soldier surveyors were attached to the party during the field season. They fully completed their course of instruction in the different branches of survey required, and were sent back to their respective regiments in May 1890.

111. The programme of work for the coming field season is as follows:—

The triangulation of about 600 square miles in the Bori forest reserve, and in the second class forests in sheets Nos. 23, 34 and 35: the detail survey of about 550 square miles in the Sáonligarh and Bowergarh forest reserves, and in the second class forests in sheets Nos. 23 and 24: traversing of the boundaries, fire lines, roads, etc., in the ground to be triangulated: the classification of forest growth and soil of the area to be surveyed in detail.

112. The recess office of the party at Mussooree was inspected by the Deputy Surveyor-General, Trigonometrical Branch, in October 1890, and he has expressed much satisfaction at the highly efficient state in which he found it.*

BOMBAY PRESIDENCY.

No. 17 Party.

113. Colonel Pullan superintended the field operations and remained in charge of this party during the greater part of the year, but proceeded on privilege leave on the 15th September 1890, handing over charge to Mr. A. M. Lawson, Surveyor.

Personnel.

Colonel A. Pullan, S. C., Deputy Superintendent, 2nd grade, in charge to 15th September 1890.
Mr. A. M. Lawson, Surveyor, 2nd grade, in charge from 15th September 1890.
„ S. F. Norman, Assistant Surveyor, 1st grade.
„ C. A. Norman, Assistant Surveyor, 1st grade.

Sub-surveyors.

R. V. Joshi, G R. Bhopatkar, Ram Rao, Yadao, N. V. Bhopatkar and 27 others.

114. The party took the field on the 1st November 1889, closed field work about the end of May 1890, and returned to Poona, opening office for recess duties on the 8th June.

115. The work done was principally

* Colonel Wilmer reports very favourably of all his European assistants, *viz.*, Messrs. Christie, Gwynne, Keating, Campbell, Warde and Shaw, especially of the first and third; and also on the following sub-surveyors:—Azim Khan, Prem Raj, Mahommed Zakaria, Gurdatt Singh, Hyder Ali, Karimdad Khan, Mahadeodaji, Surjan Singh, and Abbas Ali, and also his head writer, Syed Zille Husnain.

in continuation of that of the preceding year and restricted as before to the survey of forest tracts. The party, as usual, was divided into three sections. Camp No. 1, under Mr. Lawson, was employed in the Southern Circle on 4-inch surveys in the Supa *taluka*, North Kanara district, and on 8-inch surveys in Yellapur *taluka*, North Kanara, and Kalghatgi *taluka*, Dharwar district.

Camp No. 2, under Mr. S. F. Norman, was employed in the Northern Circle on 4-inch and 8-inch surveys in the Khed *taluka*, Poona district; in the Karjat, Kalyan and Bhiwandi *talukas*, South Thana district; and in the Sirur, Bhimtadi and Shrigonda *talukas*, Ahmednagar district. It also undertook a survey on the 16-inch scale of the *babul* reserves, at the request of the Conservator, Northern Circle, and with the approval of the Local Government.

To No. 3 Camp was allotted the preliminary triangulation and traverse work in advance in the Panvel and Pen *talukas*, Colaba district, and in the Bassein and Salsette *talukas*, Thana district.

The work done by each section will now be reported on separately.

116. In No. 1 Camp, the total area surveyed amounted to 343 square miles, of which 107 square miles were on the 4-inch scale and 236 on the 8-inch scale. The triangulation and traversing, which was carried on under great difficulties, covered an area of 340 square miles, of which 40 square miles are in advance for next season's detail survey.

With the exception of a small area near Kalghatgi, the country operated in by this section was of an exceedingly trying and difficult nature, being for the most part mountainous, with narrow valleys and ravines all covered with dense forest excepting some small swampy rice-patches. The villages were so far apart that the surveyors had frequently to camp within the forest. Labour was scarce and supplies had to be brought from a distance; and, to add to these difficulties, the climate is very unhealthy. The out-turn that has been accomplished by this section under the above circumstances is very creditable.

117. The area surveyed in detail by No. 2 Camp was 168 square miles, of which 51 square miles were on the 4-inch scale, 98 on the 8-inch scale, and 19 on the 16-inch scale. It also completed 40 square miles of supplementary triangulation and 346 linear miles of traversing.

118. No. 3 Camp was solely employed upon advance triangulation and traversing for the topography of the ensuing season, and it completed 446 square miles of triangulation and 620 linear miles of traversing.

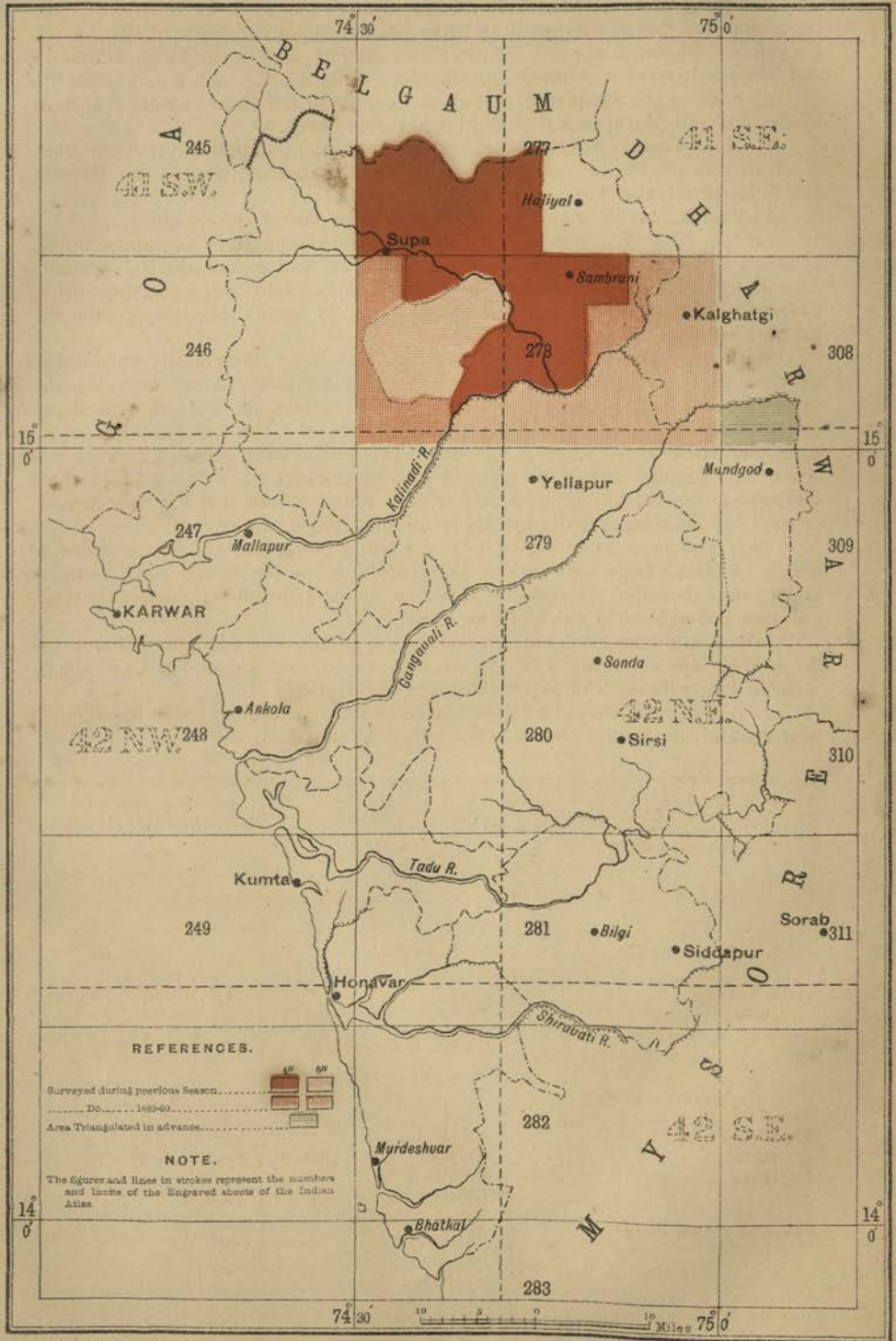
119. The total out-turn of the season and the areas surveyed in the different districts and *talukas* are shown in the following statement:—

Circle and District.	Taluka.	Area in square miles.		
		4-inch scale.	8-inch scale.	16-inch scale.
Southern Circle.				
North Kanara	Supa	107	...	...
Ditto	Yellapur	...	163	...
Dharwar	Kalghatgi	...	73	...
Northern Circle.				
Poona	Khed	51	35	...
South Thana	Karjat	...	15	...
Ditto	Kalyan	...	35	...
Ditto	Bhiwandi	...	14	...
Poona and Ahmednagar	Khed, Sirur, Bhimtadi, Shrigonda	...	...	19
	Totals	158	335	19

BOMBAY SURVEY.

INDEX TO THE FOREST SURVEYS IN THE SOUTHERN CIRCLE (N. KANARA).

No. 17 PARTY.



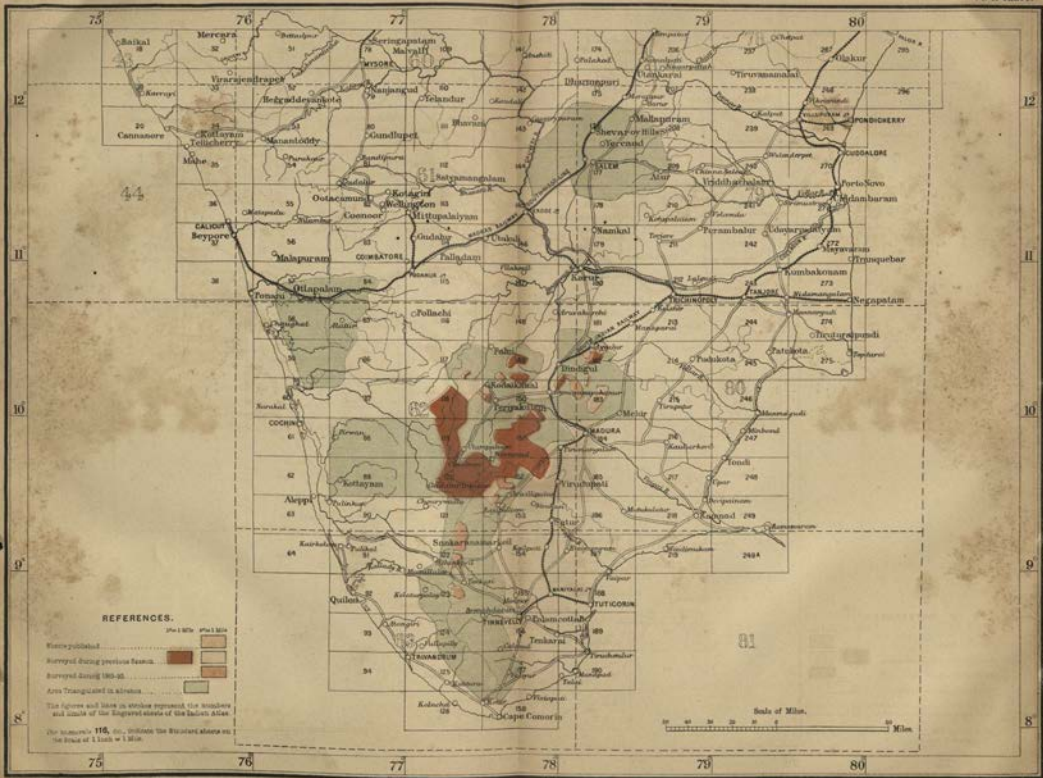
Reg. No. 328, S. I. D.—2-1-01.—500.

Photo. S. I. O., Calcutta.

MADRAS SURVEY.

INDEX TO THE SURVEY OPERATIONS IN MADRAS.

No. 19 PARTY.



120. The accuracy of the detail survey was tested either by chain traverses, or, (where owing to the nature of the country this could not be effected) by examinations *in situ* by the executive officer and the European assistants. Of the work done by No. 1 Camp, every plane-table was tested either by Colonel Pullan or by Mr. Lawson, and the result was the re-survey of parts of four sections found inaccurate. The detail work of No. 2 Camp was tested by Colonel Pullan and Mr. S. F. Norman by 203 linear miles of traverse lines in addition to examinations *in situ*.

121. The fair mapping completed during recess (which included some arrears in the Northern Circle) embraced an area of 364 square miles on the 4-inch scale; 168 on the 8-inch scale, and 14 on the 16-inch scale. The computations of the whole of the triangulation and traversing were also completed during the recess.

122. The health of the detachments employed in the Northern Circle was on the whole good. In the Southern Circle in Kanara, however, the season was more unhealthy than the previous one owing to the larger areas of evergreen forest met with. During the first two months of the field season there were numerous cases of fever. From January up to the middle of April the forests are healthy though hot, but towards the end of April and during May heavy showers fall, and the dead leaves are washed into the streams and tanks and the water is poisoned. The establishment suffered considerably during this period from malarious fever and dysentery, and many of the men had to be sent to their homes broken down before the end of the field season.

123. The programme to be carried out during the coming field season is as follows:—

In the Southern Circle, the survey of the forests in Kalghatgi will be completed, and that of Mundgod and Yellapur, south of the portions done last season, will be continued. The scale to be adopted for the above surveys has been fixed by the local authorities at 8 inches to the mile.

In the Northern Circle, the Khed *taluka* will be completed on the 4-inch and 8-inch scales, with the exception of the *baoul* reserves, which in accordance with present arrangements will be continued on the 16-inch scale. The *talukas* of Bhiwandi and Bassein will be taken up after the completion of Khed.

124. The recess office of the party was inspected in Poona by the Surveyor-General during July 1890 and he was well satisfied with the progress that had been made and with the character of the maps that had been executed.*

MADRAS PRESIDENCY.

No. 19 Party.

Personnel.

Lieut.-Colonel J. R. McCullagh, R. E., Officiating Deputy Superintendent, 2nd grade, in charge.
Mr. C. F. Hamer, Surveyor, 2nd grade.
„ H. Todd, Surveyor, 4th grade.
„ R. Todd, Assistant Surveyor, 1st grade.
„ T. J. J. Mills, Assistant Surveyor, 2nd grade.

Sub-surveyors.

T. Raghava Ayengar, V. Tiruvenkataswamy Mudaliar, Lachman D. Jadow, Balaji Dhondiba, Govindaraju Mudaliar, and 8 others, and 10 apprentice sub-surveyors.

125. This party, of the strength shown in the margin, left recess quarters during the first week of September 1889 for the field of operations in the three districts of Salem, Madura and Tinnevelly, to continue the survey of the forests therein. One section of the party was allotted to each district, the work to be undertaken in the first-named being triangulation and boundary traversing, and in the two latter traversing, topography and some supplementary triangulation.

126. The triangulation carried out in the Salem district is to the northward and westward in extension of that done in the previous year, and embraces an area of 650 square miles. The number of stations at which observations were taken was 114, and 247 points and 239 heights were fixed. In Madura, the triangulation was extended over an area of 320 square miles in the Palni

* The services of the European assistants, Messrs. Lawson, S. F. Norman, and C. A. Norman, are favourably reported on. The following sub-surveyors are mentioned as being deserving of commendation :— R. V. Joshi, G. R. Bhopatkar, Ram Rao, Yadao and N. V. Bhopatkar.

hills; 29 stations were observed at, from which 125 points and an equal number of heights were determined. The supplementary triangulation above referred to had to be undertaken to provide some extra points for the detail survey on the 4-inch scale, that originally executed having been intended for topography on the 1-inch scale.

127. The traversing carried out during the season amounted to 611 linear miles and included the boundaries of the forest reserves which were subsequently surveyed in detail, as well as of others to be surveyed next season. At first some difficulties were experienced in Madura and Salem owing to the boundaries not being sufficiently cleared, by which delay was occasioned, but after a time matters improved considerably. The physical difficulties that were encountered and had to be overcome were very great and admitted of only very slow progress; hence a large number of surveyors had to be employed on the traversing to enable it to keep pace with the topography.

128. During the season, the amount of topography that was accomplished amounted to 214 square miles on the scale of 4 inches = 1 mile. This out-turn, though an improvement on that of the previous year, is still a good deal short of what it was hoped might be done, but this is in a great measure due to (1) the difficulties connected with the boundary traverses and the number of men that have to be employed on that particular duty; (2) the very difficult and inaccessible nature of the ground which greatly hindered locomotion from place to place; (3) the unhealthiness of the forest tracts combined with unfavourable weather; and (4) the large proportion of sub-surveyors being only pupils and partially trained men.

129. The country in which the operations were conducted corresponds closely with that described in previous reports. In the Salem district most of the reserves were situated on moderately high but rather rugged hills; while in the Madura district, though a few of the reserves were on low hills and fairly easy ground, others again were on high and difficult mountains, and in Tinnevelly the mountains were not only high but very precipitous, the ground being exceedingly difficult to move about in. As mentioned also in other reports, it was at times no easy matter to procure supplies, labour and carriage. Coolies were very averse to going into the hills and forest, and, when secured, never remained for any length of time; as the work often lay at considerable distances from villages, and as it was impossible to obtain a fresh lot of men daily, it was necessary to keep them as long as possible.

130. The duration of the field season was a full six months, and it was far from being a healthy one; but it is probable that this may always be expected now, as long as the operations are carried on in the forests which are in proverbially unhealthy tracts. Throughout the season there was more or less sickness: the European officers escaped fairly, but the natives suffered a good deal. There was a severe outbreak of cholera in the Madura district which gave cause for much anxiety. During the season, one apprentice was invalided, while a great many of the men deserted from fear.

131. During the recess, the various computations have been brought up to date and the fair mapping of eight reserves in Madura and ten reserves in Tinnevelly has been completed, the whole being included in 23 sheets. In addition to the fair mapping, a large amount of time and labour was of necessity expended on the preparation of tracings of the reserves which had to be sent to the district forest officers for the verification of boundaries, rights of way, holdings, &c., within the forest limits, but though this operation adds greatly to the work in office, it seems to be unavoidable, owing to the apparent impossibility of getting full or reliable information from forest subordinates on such matters.

132. The programme for next season is briefly as follows:—Two sections of the party will continue topographical operations in Madura and Tinnevelly districts respectively, while the work in the Salem district will be suspended, the section of the party hitherto working there being moved to south Coimbatore to commence the survey of the Anaimalais, and subsequently some other adjacently-situated reserves if time permits.*

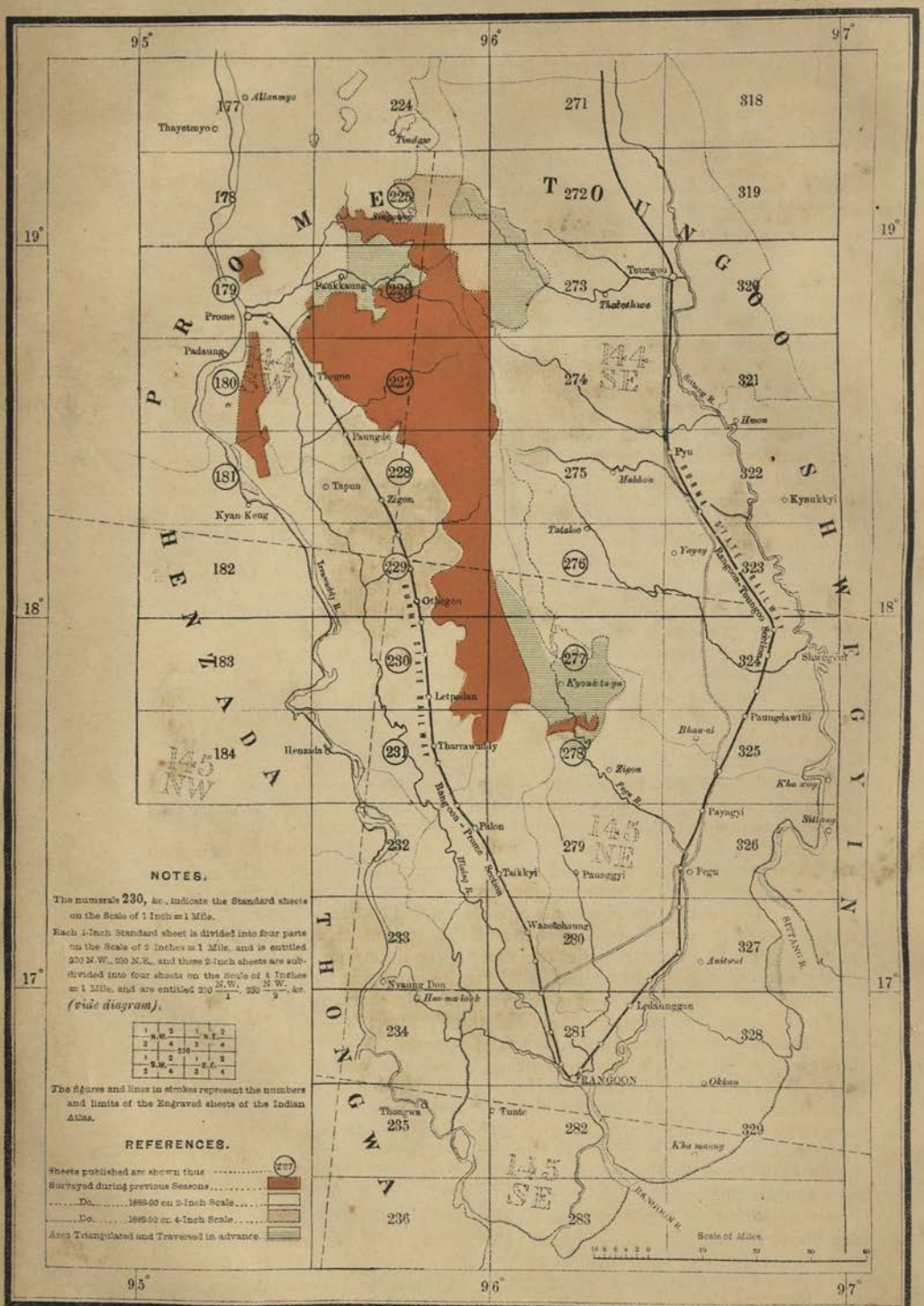
* Of the European assistants, Colonel McCullagh specially mentions Messrs. H. Todd, and R. Todd and T. J. J. Mills as having done good work both in field and recess.

Of the sub-surveyors, the men most deserving of mention are Balaji Dhondiba, Anantarao Dhondiba, Raghava Ayengar, Tiruvenkataswamy, Govindaraju Mudaliar and Eknath Battu.

BURMA SURVEY.

INDEX TO THE FOREST SURVEY IN LOWER BURMA.

No. 20 PARTY.



NOTES.

The numerals **230**, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.

Each 1-Inch Standard sheet is divided into four parts on the Scale of 2 Inches = 1 Mile, and is entitled 230 N.W., 230 N.E., and these 2-Inch sheets are sub-divided into four sheets on the Scale of 4 Inches = 1 Mile, and are entitled $230\frac{N.W.}{1}$, $230\frac{N.W.}{2}$, &c. *(vide diagram).*

1	2	1	2
3	4	3	4
230			
1	2	1	2
3	4	3	4

The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.

REFERENCES.

Sheets published are shown thus 227

Surveyed during previous Seasons .....

.....Do. .....1889-90 on 2-Inch Scale .....

.....Do. .....1889-90 on 4-Inch Scale .....

Area Triangulated and Traversed in advance.

Reg. No. 265, S. I. D.—9-1-91.—550.

Photo., S. I. O., Calcutta.

LOWER BURMA.

NO. 20 PARTY.

133. Colonel Beavan has held charge of this party throughout the year and the strength thereof is shown in the margin.

Personnel:

Colonel R. Beavan, S. C., Deputy Superintendent, 3rd grade, in charge.
Mr. J. A. Barker, Surveyor, 4th grade.
Mr. A. Ewing, Assistant Surveyor, 2nd grade, from 13th December 1889.
Mr. P. Beechey, Assistant Surveyor, 2nd grade, up to 31st May 1890.
Mr. H. A. Charrier, Assistant Surveyor, 3rd grade, from 7th November 1889.

Sub-surveyors.

Venkatswamy, Abdulla Khan, Sharf-ud-Din, Girdhari Lall, Hpo Moung, Amjad Ali and 19 others.

134. This party has been engaged in executing surveys for the Forest Department on the scale of 4 inches to the mile, in the reserved forests of North Naweng and Kabaung, the former being in the Prome district and the latter in Toungoo district: these forests are contiguous, being divided by the watershed of the Yoma range. A small portion of the West Swa forest was also surveyed, and about 8 square miles in the Thayetmyo district to complete sheet No. $225\frac{N.E.}{3}$.

135. The operations were commenced on both sides of the Yoma range. A detachment under Mr. Barker left Rangoon on the 22nd November 1889, proceeding by rail and river steamer to Alanmyo, and thence marched to Singoung, where work was commenced on the 15th December. The remainder of the party went by rail to Toungoo and thence reached their ground by marching up the bed of the Kabaung river: on this side the work commenced on the 20th December. Considerable delay was caused in starting for the field owing to an outbreak of cholera among the *khalásis* while on their journey from Hazaribagh to Calcutta, in consequence of which the first batch of men were not allowed to embark; so instead of reaching Rangoon on the 10th November, as had been previously arranged, they did not arrive till the 4th December.

136. The season proved to be an extremely unhealthy one. The forests under survey are always malarious, and this year fever was more than usually prevalent. In consequence most of the party, for the greater part of the season, were on the sick list and unable to do efficient work.

137. The rainy season commenced earlier than usual. It is generally dry up to the latter end of May, but this year heavy rain fell in April and throughout the month of May. Owing to these difficulties, the out-turn of work for the season was naturally a small one, comprising only 168·5 square miles of topography, and 240 square miles of traversing. The area of 4-inch survey that had been anticipated was 300 square miles, and therefore the reduced out-turn has increased the mileage rate of the detail survey very considerably.

138. The field operations were continued as long as possible, until 20th May, when the monsoon set in and every exertion was made, when the sickness had somewhat abated, to make up for the time that had been lost thereby, but during the last month, the work was again impeded by bad weather. Thus the season proved to be a disastrous one, and the amount of work obtained is as much as could be expected, under the adverse conditions met with. The detail survey was all carefully tested and found for the most part to be accurate.

139. The country surveyed is of a very difficult character, the forest being very dense, especially on the west side of the Yoma watershed. This impeded the traverse operations considerably, as the lines in all cases had to be cut through thick forests, the progress being at the rate of half a mile per diem only. With the exception of a few Karens, who have special tracts allotted to them, there are no inhabitants, and thus it was a matter of serious difficulty to keep the large number of men at work supplied with food. The only route to the Upper Kabaung valley is up the bed of the river, which becomes practicable for elephants in December, but in the early part of the season it is somewhat dangerous owing to quicksands.

140. During the recess season, six standard sheets on the 4-inch scale have been drawn for reproduction, and four 2-inch sheets for reduction. The traverse computations have all been brought up to date. One chart of triangulation and five charts of traversing have been prepared, and lists of co-ordinates of traverse points have been compiled for the General Report. The apprentices and junior

sub-surveyors were instructed in surveying, and also in computations and map drawing.

141. During the ensuing season it is intended to complete the survey of the Kabaung forest on the 4-inch scale and to take up the remaining portions of sheet No. 226 on the 2-inch scale. These areas are estimated at 200 square miles of 4-inch, and 150 square miles of 2-inch work. The area to be triangulated and traversed in advance for season 1891-92 includes the Bhongdong and Pyu reserves, aggregating about 250 square miles.*

CADASTRAL SURVEYS.

TIPPERAH, CHITTAGONG AND BACKERGUNGE DISTRICTS, BENGAL PRESIDENCY.

NO. 2 PARTY.

142. The work which this party was conducting in the Central Provinces having been completed, it was transferred to Bengal to take up the survey and *khasra* writing of some Wards' estates and Government *khas mehals* in pargana Serail, district Tipperah, and, in the Island of Dakhin Shabazpur, district Backergunge, a detachment, which had been at work in the Chittagong district during the past season, was also attached to the party, and the work was therefore conducted by three widely-separated detached sections, under one general superintendence, as shown marginally.

Personnel.

Colonel E. H. Steel, Officiating Deputy Superintendent, 2nd grade, in charge up to 6th August 1890.
Mr. F. Grant, Officiating Deputy Superintendent, 4th grade, in charge from 7th August 1890.

Serail Detachment.

Mr. P. C. H. Smart, Assistant Surveyor, 1st grade.
Babu Sarat Chunder Sen, Assistant Surveyor, 3rd grade.
13 sub-surveyors, computers, &c.
101 *munsarims* (field surveyors).

Chittagong Detachment.

Mr. W. J. O'Sullivan, Surveyor, 3rd grade.
Mr. C. G. Lee, Assistant Surveyor, 2nd grade.
18 sub-surveyors, computers.
223 *munsarims* (field surveyors).

Dakhin Shabazpur Detachment.

Mr. J. McHatton, Surveyor, 4th grade.
11 sub-surveyors, &c.
98 *munsarims* (field surveyors).

143. In all the three detachments the principal operations were the same, *i.e.*, traversing of village boundaries, field survey and writing of the record of rights, but in Chittagong and Dakhin Shabazpur, some topographical work on scales of 2 inches and 8 inches to the mile, respectively, was also carried out.

144. Colonel Steel held charge of the party up to 6th August 1890, when his health necessitated his going on three months' privilege leave and the charge devolved on Mr. F. Grant, the senior assistant in the party. Mr. McHatton having been also granted three months' privilege leave, from the 26th July 1890, Mr. P. C. H. Smart was put in charge of the Dakhin Shabazpur detachment. On Mr. McHatton's recall from leave on the 20th October, Mr. Smart was put in charge of the Serail detachment.

145. The party, which had been divided during the recess of 1888-89, one portion being at Kamptee and the other at Mussooree, met on or about the 12th November at Naraingunj, where it was detained partly by stress of bad weather and partly making preliminary arrangements for taking the field, till the 26th November.

Survey of the Serail pargana, Tipperah district.

146. The detachment told off for the survey of Serail reached its ground on the 1st December and started work on the 4th idem. The traverse surveyors met with difficulties at the very commencement from the want of proper demarcation of village boundaries, as the little that had been done by the sub-mana-

* Colonel Beavan reports favourably of the work performed by Messrs. Barker, Ewing and Beechey, all of whom worked hard and well during an exceptionally trying season.
Almost all the native assistants are also favourably mentioned.

BENGAL SURVEY.

INDEX TO THE CADL. SURVEY OF PARGANA SERAIL, DIST. TIPPERAH.

No. 2 PARTY.

Reg. No. 281, S. I. D.—13-9-90.—1,050.

Reg. No. 281, Bengal.—26-11-90.—702.

Photo., S. I. O., Calcutta.

ger, consisting of thin bamboo poles stuck in the ground, had been destroyed by the villagers, and the headmen were very loth to come forward and point out their boundaries. As no sketch maps had been supplied or were even ready for issue, the sub-surveyors had to depend on the knowledge or honesty of any one they could get to show the run of the boundaries between villages, till the 4-inch maps of the old revenue survey were obtained from the Collectorate at Comillah, and tracings of these were given them as guides. No tri-junction marks of any kind had been put down, and, notwithstanding every care, many stations were fixed which were afterwards found to be off the boundary and had to be removed and the work revised. Permanent marks consisting of stone prisms, 2 feet by 6 inches, were embedded at all triple junctions and their adjoining stations, and at all salient bends of boundaries in triplets. This work could not, however, be done at the time of survey, as the stones had not arrived when the work was started, and the entire want of means of transport of any kind excepting boats rendered any attempt at doing so impossible, as the traverse surveyors would have had to utilize their *khalásis* to convey the stones, which would have so delayed their work that they would have been unable to keep ahead of the field-surveyors. The sub-surveyor or his *tindal* had therefore to go over the ground again with their men after the traverse work was finished and replace the temporary marks with stones; 2,600 stones were thus embedded and the headmen of villages were warned of their responsibility in regard to their preservation.

The following table shows the number of villages and area traversed :—

District.	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Tipperah	333	278	5,193	318

147. The field-by-field survey was performed in the usual way by cutting up the skeleton plots into quadrilaterals of 10 to 20 acres each in the open country, and then filling in the details. Village sites which were surrounded by trees and dense hedges of all kinds were first cut up into convenient blocks by prismatic compass traverses and the details were then filled in with a plane table and sight rule. No local agency could be employed on this portion of the work, as there were no qualified candidates forthcoming, and time did not allow of training any. The work was done entirely by imported Hindustani *amins*.

148. The European assistants, supervisors and *munsarims* ran 192 miles of preliminary and 254 miles of final test lines through the work, which was found to be extremely accurate. The country is a dead level, intersected by several large marshes, and the field survey would have been easily completed early in the season, notwithstanding the withdrawal of 20 *kistwar amins* to help in *khanapuri* work, had it not been for the heavy intermittent rains which set in during the latter part of April, causing constant interruption of work and finally, aided by high-spring tides, putting an entire stop to it, by flooding all the fields in the low-lands adjoining the marshes. About 20 square miles of marshy land were consequently left unfinished.

149. The area completed cadastrally on the 16-inch scale is shown in the subjoined table :—

District.	Number of villages.	Number of fields.	Area in square miles.
Tipperah	283	339,548	261

The average area of the field in the above area is 0·5 of an acre.

150. The *khanapuri*, or writing of record of rights, was at first attempted to be done solely by local agency. A list of 40 Bengali applicants for this work was sent by the sub-manager of the estate with a statement of their qualifications; of these 30 were selected but only 26 joined. Although they were promised contract rates more than twice as much as those which prevail in the

Central Provinces, they were dissatisfied; moreover, when work actually commenced, it was found that their rate of progress was quite incommensurate with the amount to be completed, and, notwithstanding a promise of still further increased rates, if they would increase their daily out-turn, they would not send in more than an average of 25 to 30 numbers a day; it was consequently necessary to withdraw 20 Hindustani *amins* from the cadastral work to assist in the *khanapuri*, and they, with the help of Bengali *mohurrirs* who received ₹10 each, wrote an average of about 80 numbers daily. This work was also delayed by the unwillingness of the cultivators to attend when called on to do so, and thus papers which could have been prepared on the spot, had to be prepared afterwards at the village, which caused a loss of time to the *amin*. Nor would the two or three representative men of the village who did attend, keep out with the *amin* all day, but only for a stated time, and no amicable or legal measures would persuade them to do more.

151. One or two cases of active obstruction were brought to notice at the beginning, but these were promptly punished by the sub-divisional officer and matters subsided into a sort of passive opposition; a great deal of this, however, must be attributed to the Bengali's love of ease and leisure, and in the case of the richer tenure-holders, to pride of purse and love of litigation disposing them to despise attendance on the *amin* and to trust to appeals in the Settlement officer's court for rectifying any errors committed by the *amin* through their non-attendance. Owing to these adverse circumstances, the amount of *khanapuri* work finished, as shown in the subjoined table, was much less than was anticipated, leaving an area of 65 square miles of which the field survey has been completed; this area, together with 20 square miles of which the survey also remains to be done, is left over for next season.

District.	No. of villages.	No. of *khasra* entries.	No. of fields.	Area in square miles.
Tipperah	253	211,300	256,602	196

152. The Serail ward's estate is contained in 299 villages, 9 of which lie outside the boundary of the *pargana* proper. The lands in these villages are divided among 4 chief *mehals*, the Collectorate *tauzi* numbers of which are 1298, 1299, 1300 and 1301; the Ward, Babu Ashutosh Nath Roy, is the sole proprietor of the first two *mehals* and possesses a 12-anna share in *mehal* No. 1300 and a 7-anna share in a portion of No. 1301. These villages also contain other lesser estates, with distinguishing *tauzi* numbers; and the lands of all these large and petty estates are intermingled with one another in numerous small plots or *chaks*, scattered over almost every village without any demarcation, the cultivators themselves not knowing their exact limits. To separate these lands has been the main difficulty of the work, and this could only be done by careful comparison of the old *thakbust* maps of 1861-62 with the present survey: when the great alterations which necessarily have taken place in the field divisions, especially in the position of village sites, during this interval of 28 years and more, and the inaccuracy of the old maps are taken into consideration, the difficulty of identifying these scattered plots may be imagined.

153. The cost of the work has been necessarily heavy owing to—

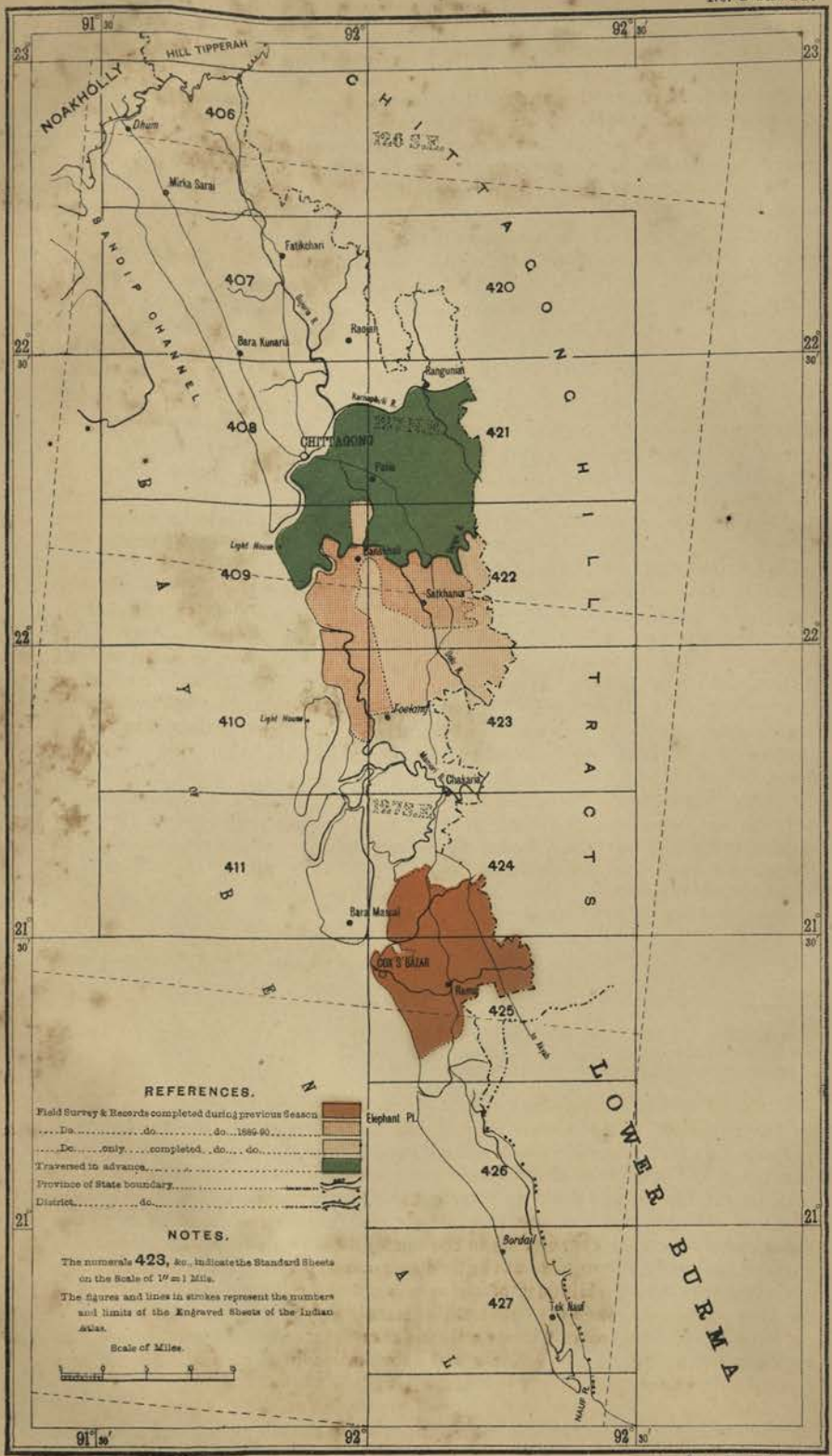
(1) Total want of local labour for chainmen.
(2) High wages of imported menial labour.
(3) Double labour in traverse and stone-embedding, owing to entire want of means of transport.
(4) Prolonged operations in consequence of the non-attendance of the *rayats* and for want of means of transport.
(5) Elaborate system of preparing the records, and the enhanced contract rates for work, which are more than double those in other provinces.
(6) The apathy, and want of training of the Bengali *amins* and *mohurrirs*.

154. During the field season, Mr. C. A. Radice, C.S., joined the camp in

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT CHITTAGONG.

No. 2 PARTY.



REFERENCES.

Field Survey & Records completed during previous Season

....Do.....do.....do....1889-90

....Do.....only....completed...do....do.

Traversed in advance

Province or State boundary

District.....do.

NOTES.

The numerals **423**, &c., indicate the Standard Sheets on the Scale of 1⁄ = 1 Mile.

The figures and lines in strokes represent the numbers and limits of the Engraved Sheets of the Indian Atlas.

Scale of Miles.

Reg. No. 243, S. I. D.—16-9-90.—1,050.

Reg. No. 248 R., Bengal.—26-11-90.—793.

Photo., S. I. O. Calcutta.

order to receive a course of training in survey work, and every assistance and instruction was afforded him.

155. The Settlement officer, Babu Kali Shanker Sen, came to Serail about the 13th March and gave much valuable help and advice. His presence in the district ensured better attendance of the *rayats*. The officer in charge of the camp was much indebted to the sub-manager, Babu Beni Madho Chatterjee, throughout the operations, for his great aid in drawing up instructions for the writing of the records suitable to the district, in pointing out all the difficulties and peculiarities to be met with, and for his untiring interest and zeal in forwarding the work.

156. The health of the detachment was on the whole good throughout the season. There was only one fatal case of cholera, Golam Ali, sub-surveyor, who evidently caught the disease in Narainganj and died immediately on his arrival in camp. There were no other casualties.

Survey of the Chittagong District.

157. The detachment employed on this survey, which was absorbed into No. 2 Party from 7th November 1889, continued the cadastral and topographical survey in Thana Ramoo, and extended its operations into Thanas Banskhali, Satkania and Pattia during the season. The scale of the cadastral survey was 16 inches=1 mile; that of the topographical was 2 inches=1 mile, but as the Settlement officer required, in addition to the 2-inch sheets, skeleton maps of the hilly portions showing roads, streams and main water-sheds on the 16-inch scale, these features had to be traversed.

158. Stones for permanently marking the stations did not arrive till April and baked clay pipes were at first embedded at all stations; 15,232 of these were used, but after receipt of the stones, all tri-junction points with their adjoining stations, and the stations at all salient angles of boundaries were marked with them; 1,075 stones in all were embedded. Great difficulty was experienced in transporting these stones, as many of the streams had dried up and boats could not be used, and it was only with the help of carts from the Collectorate *Nazir*, and of an elephant kindly lent by the Commissioner, that this work was done.

159. Azimuths were observed at 80 stations and double chain measurements were carried throughout the whole work. The following table shows the total area completed in traverse. About 285 square miles are in advance, on which to commence next season's field survey:—

District.	No of villages.	No. of sub-traverses.	No. of traverse stations.	Area in square miles.
Chittagong	458	595	19,049	717

160. The field survey was executed almost entirely by Hindustani *amins*, it having been found almost impossible to utilize local agency for that purpose. It had been intended to complete the whole of Banskhali and Satkania, but the nature of the country presents such great physical difficulties that it was found impossible to carry out the whole programme of field survey. The very crowded state of the homesteads, the excessively small size of the fields, which averaged 0·10 acres in the open and 0·07 amongst the groves and gardens, delayed the progress of the field surveyors to a most serious extent; the average out-turn of the Hindustani *amins* was only about two-thirds of what could be done by the same men in the North-Western Provinces.

161. Test lines of one linear mile for every square mile of survey were run by European agency, and 1¼ linear miles by native inspectors. The average quality of the work was found to be first class.

162. The country operated in varied greatly, consisting of jungle-clad low hills, undulating ground, cultivated and uncultivated valleys, and of culturable

plains sloping down to the Bay of Bengal. The total area of detail survey is shown in the following table :—

District.	No. of villages.	No. of fields.	Area in square miles.	
			Cadastral, 16-inch scale.	Topographical, 2-inch scale.
Chittagong	164	1,500,000	380	68

163. The *amins* employed on the *khanapuri* were entirely Bengalis and were chiefly obtained locally. They were quite new to the work and had to be trained to read the maps before they could be trusted to enter the numbers on them. The best workers were those who came from the Jessore and Nuddea districts. Those obtained locally proved to be a source of the greatest trouble, annoyance and anxiety, and were the cause of constant complaints. Their chief aim seemed to be to get allotted to them the record writing of villages in which they had some interests, so that they might falsify the records to suit their own purposes. If this were not discovered until the records had been lodged in office, an entire revision, or at least a very minute examination would be rendered necessary, and much delay and useless expense caused. Under the circumstances, Mr. O'Sullivan thinks it is a mistake to employ local *amins* for this work, and believes that it would be far better to get men from other districts, who can have no local interests at all.

164 The record writing also presented peculiar difficulties, owing to the numerous descriptions of tenures and under-tenures, the immense number of tenure-holders and the thousands of *mehals* or estates, which have been still further split up by sales, &c., all bearing separate Collectorate *tauzi* numbers which must find a place in the Government *khewats*. Purchasers and heirs have neglected to register changes in the *khewats*, and *zamindars* and proprietors withheld or falsified the *tauzi* papers they were ordered to prepare each for his own estate. *Amins* were untrained and inclined to be venal, and wilfully neglected or misunderstood the orders given them, and the consequence has been that an entire revision of the *mehal* entries has been found necessary. The land is most intricately parcelled out and the task of getting a clear statement of the records of rights in this district is an exceptionally difficult one.

165. The inhabitants were very slow in giving assistance, and were generally inimical to the survey operations. Local menial labour was obtainable, but of an unsatisfactory kind, as the men, chiefly Mohammedans, looked to their own convenience, and not to the benefit of the work.

The *khanapuri* work completed was as follows :—

Districts.	No. of villages.	No. of *khasra* entries.	No. of fields.	Area in square miles.
Chittagong	96	320,439	94,320	239

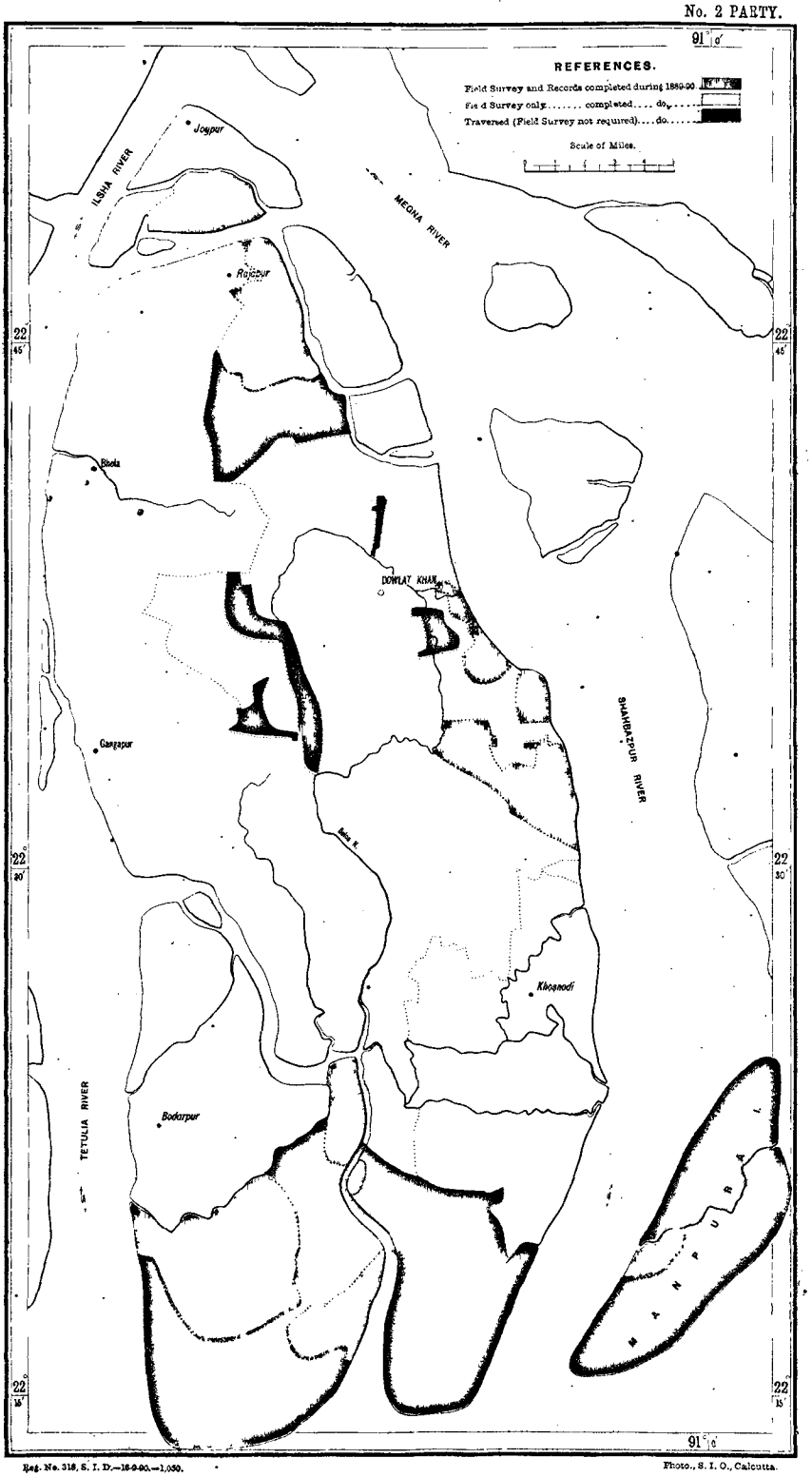
The preparation of the records for the Settlement officer has been very slow owing to the necessity for revisions as explained above, and to the tediousness of separating the lands of the various *mehals* and *taluks* as occurred in Serail; the cost has been much enhanced in consequence, as well as from the great multiplicity of fields.

166. Mr. O'Sullivan reports that "the work derived the greatest benefit from the attention given it by F. A. Slack, Esq., C.S., Settlement officer, and to him alone is due the improved attendance of those interested." He also says, "to the Settlement officer is due the most important part of the instructions to the *khanapuri amins* and the attendance of the *zamindars* and *rayats*. His untiring and personal inspection of that work out in the field had an excellent effect on the people and induced them to interest themselves in what was being done." Mr. Grant adds, "personally I am very grateful to him for his advice and kindness, and without his help I should often have been stranded."

BENGAL SURVEY.

INDEX TO THE CADL. SURVEY OF PARG. DAKHIN SHAHBAZPUR DIST. BACKERGUNGE.

No. 2 PARTY.



Reg. No. 316, S. I. D.—18-9-90.—1,050.
Reg. No. 316 B., Bengal.—26-11-90.—702.
Photo., S. I. O., Calcutta.

Survey of Dakhin Sharbazpur, District Backergunge.

167. This detachment took the field on the 4th December and closed work on the 12th June.

168. The first instructions received as to the amount and kind of survey required, gave ten *khas mehals* or Government estates and 41 villages comprising the Dakhin Shabazpur *zamindari* now under the management of the Court of Wards, which were to be surveyed cadastrally on the scale of 16 inches = 1 mile. Subsequently the Settlement officer asked for the topographical survey in the 8-inch scale of 9 other Government estates, but, owing to the late date on which this work was commenced, it was only possible to finish 3 of the estates. These estates consist of jungle and sandy *char* land, and there is no cultivation in them whatsoever. All cultivated and culturable lands were surveyed field by field, but all jungle land and the sandy *chars* were surveyed in block. The work was not contiguous, but scattered over an area ranging about 50 miles from north to south and 10 miles from east to west.

169. The following table shows the area completed in traverse :—

District.	No. of villages.	No. of sub-traverses.	No. of traverse stations.	Area in square miles.
Backergunge	73	205	4,632	285

Fifty azimuths were observed, to check angular error, and a connection made with Gangapur Great Trigonometrical Survey station. Stone prisms were embedded at 1,845 theodolite stations; these have been placed in charge of the lessees and *tahsildars* in the Government *khas mehals* and of the manager in the Wards' estates.

170. Only 9 villages had been demarcated when the survey operations commenced on the 4th December, and these were done in such a perfunctory manner that the work was practically useless. The *amins* had therefore to find the boundary as best they could, with the result, that after completion of survey, when the boundaries were compared with the *thak* maps, numerous discrepancies were found. The *thak* maps also were found to be so unreliable that it was impossible to adjust the boundaries in accordance with them, and it was only after receiving the old 4-inch maps, surveyed in 1863-65, that the boundaries could be fairly adjusted.

171. The *Kistwar* or field-by-field survey was done entirely by Hindustani *amins*, and as no local labour was available, *khalásis* had to be recruited from Dacca and Calcutta, and the survey operations were considerably delayed in consequence. At the request of the Collector, an effort was made to utilize the services of Bengali *amins* on the cadastral survey, and 10 of these men after being duly instructed in the professional method of survey, were accordingly put on this work; but they were found to be so exceedingly wanting in energy and so thoroughly unfit to endure the physical labour necessary for work of this kind, that the experiment proved an entire failure and the men had to be eventually removed and employed on *khasra* writing.

172. The field survey was done with plane table and chain, and owing to the dense foliage and rank undergrowth the sight rule was also used in the survey of the *bagans* or orchards, which were a great feature of the country and covered one-third the entire area under survey. The average size of the field is 0·36 acres, but in consequence of the minuteness of the details in the orchards the difficulties of survey were very considerably enhanced. The total number of linear miles of *partal* survey was 515; of this 162 miles were run by European officers and 353 by natives. The work in the open fields was good and in the *bagans* fair.

173. The total area of field survey completed is given in the subjoined table:—

District.	No of villages.	No of fields.	Area in square miles.
Backergunge	51	309,697	169

174. The *khasra* writing was done by Bengali *amins* only, 30 of whom, selected by the Settlement officer, were employed on this work. But here, too, their characteristic want of energy and incapacity for hard work manifested themselves, their daily average being only 18 numbers. Every effort failed to induce them to work harder and the consequence was that only 65,186 numbers out of a total of about 1,65,000 numbers were written up during the season.

175. The Board's rules direct that the maps should be inked up and the *khatians* written and explained to the *rayats* after each day's work, but here, as in Serail and Chittagong, it was found impracticable to carry out this procedure, and this work, with statistical forms and other records, was left for more careful preparation in office during recess. The total number, of *khasra* entries checked was 21,622; of this number, 7,722 entries were checked by European officers and 13,900 by natives, or an average of 12 per cent. by Europeans and 21 per cent. by natives of the entire work.

The total amount of *khasra* writing completed is given below:—

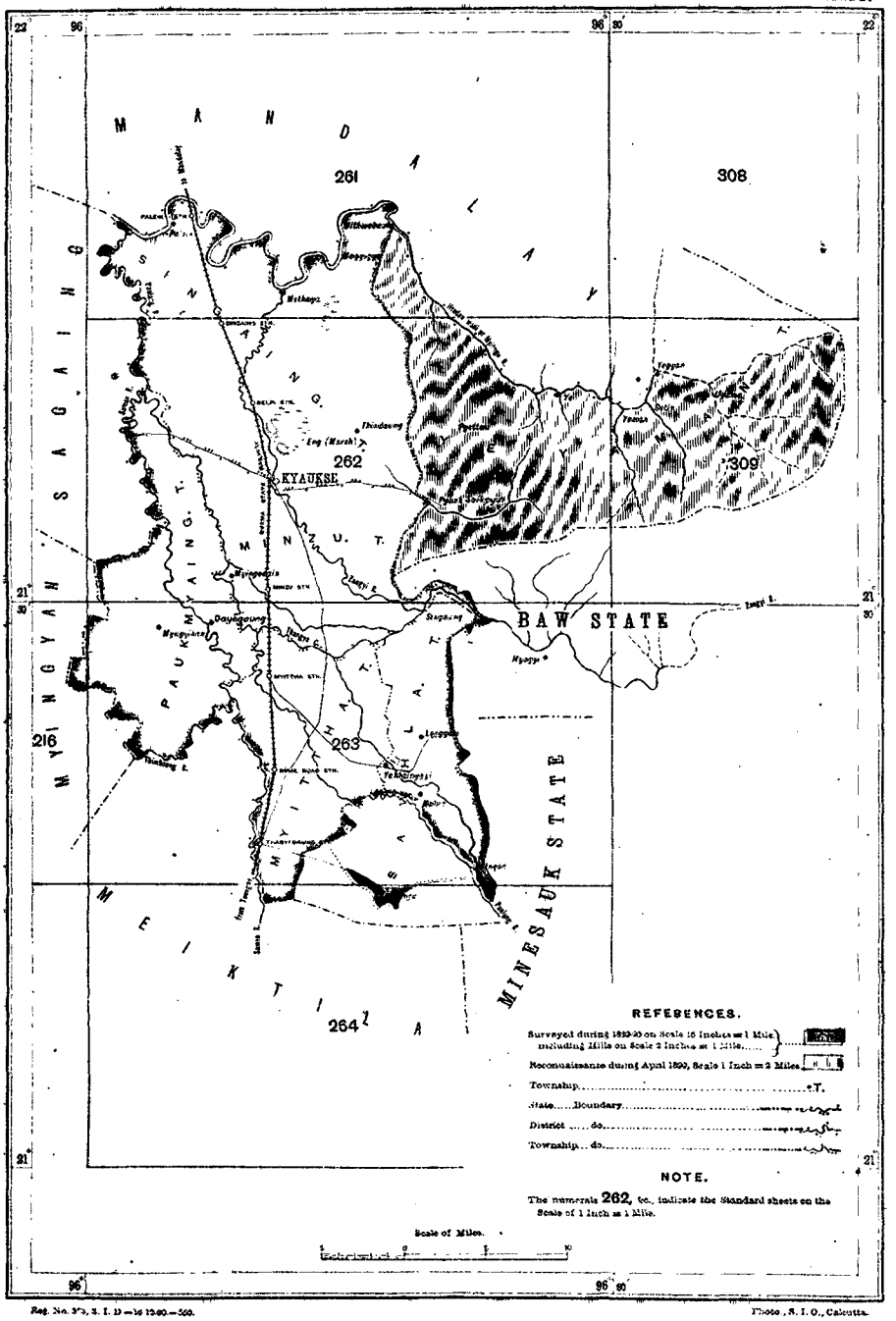
District.	No of villages.	No of *khasra* entries.	No of fields.	Area in square miles.
Backergunge	24	64,165	73,419	58

176. There is a great amount of sub-letting in Dakhin Shabazpur. There are two classes of landlords; the superior or tenure-holders and the inferior or under tenure-holders. The tenure-holder class are chiefly *talukdars*, and there are 5 classes of under tenure-holders; under these come the tenants, of whom there are 3 classes, and under these again are the *rayats* of whom there are 5 kinds. A great number of tenure-holders themselves cultivate part of the land within their tenures and let out the rest to under tenure-holders or direct to *rayats*. It frequently happens that the same person has three or four kinds of interest with regard to the same plot of land, for all which separate *khatians* have to be made. This made the work in the office very difficult and laborious, and the difficulty was added to by the existence of three different local standards of measure, the standard area in acres of each field being converted into two of these measures in the *khas mehals*, and into the third in the Wards' estates.

177. Dakhin Shabazpur is an island situated in the delta of the Ganges, at a point where the Megna river, branching off on either side of the island, debouches into the Bay of Bengal. The face of the island is subject to great alterations owing to constant diluvium and accretions. Since the survey of 1863-65, an area of about 21 square miles has diluviated on the eastern face and an accretion of 33 square miles has been effected on the south, and during the last field season, between the months of December and May, as much as two chains, in some parts, has been cut away on the eastern face of the island. Extensive *chars*, or sand-banks, to the south and east have always existed and are constantly forming, and by the silting up of the channels between them and the mainland, they are gradually becoming connected with each other and the island. Some of these have already been let out by the Government and utilized as grazing grounds, but there is no doubt that in time they will become culturable. The island has a rich, sandy soil, which yields three crops during the year in many places. Owing to the dense foliage and rank undergrowth, added to the putrid water in the numerous tanks, drains and ditches, the sanitary condition of the country is extremely bad and cholera is very prevalent. No coolie labour or wheeled traffic exists in the island, and there is only one fair-weather road from Bhola to Daulat Khan and back by Mirzakalu and Kaliganj police outpost. The inhabitants are chiefly Mohammedans, and at the early part of the season displayed a determined spirit of opposition to the survey operations, but a few prompt and judicious punishments under the Act made them more tractable. The *talukdars* were the chief offenders, and it appears that a regularly organized opposition was created by them which, however, was broken down at an early stage by the prompt action taken by the Settlement officer in the infliction of heavy fines on some of the ringleaders.

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT KYAUKSE. No. 3 PARTY.



Reg. No. 373, S. I. D.—16-12-30—500.

Photo., S. I. O., Calcutta.

178. Mr. McHatton gives the following reasons for delay in the operations, which are much the same as in the case of Serail and Chittagong:—

(1) Incapacity of Bengali *amins*.
(2) Local labour not being available.
(3) General obstruction on the part of the inhabitants.
(4) Absence of means of communication.
(5) Absence of proper demarcation.
(6) Excessive complication of tenure.
(7) Inundation of the country by spring tides.

179. The health of the party was generally good and there was only one casualty, one man having been drowned whilst swimming a stream.*

KYAUKSE DISTRICT, UPPER BURMA.

No. 3 PARTY.

180. This party, having completed the traverse work on which it had been employed for three years previously in the Central Provinces, was transferred to Upper Burma, to take up the cadastral survey of the Kyaukse district, in accordance with the programme of survey operations for Burma drawn up at a conference held in Mandalay in July 1889.

Personnel.

Mr. G. B. Scott, Deputy Superintendent, 4th grade, in charge
„ E. G. Little, Surveyor, 2nd grade, from 1st November 1889 to 31st January 1890.
„ W. C. Price, Surveyor, 3rd grade.
„ J. Connor, ditto, 4th do., from 1st February 1890.
„ O. D Smart, Assistant Surveyor, 2nd grade.
„ M. Gastaud, ditto 2nd do.
„ F. P. Walsh, ditto 2nd do.
„ W J. Baker, ditto 3rd do.
29 sub-surveyors and others.

Temporary Establishment.

167 field surveyors and others.

181. Owing to the change in the nature of the operations on which the party was to be employed, the establishment, both European and Native, had to be reorganized to suit cadastral requirements. The party, on transfer, was placed under the charge of Mr. G. B. Scott, an officer who had successfully conducted cadastral surveys in the Central Provinces and in Bengal.

182 The traverse section left Calcutta on 26th October, and the cadastral section on 20th December 1889. The traverse operations were commenced early in November, and the cadastral work in the January following.

183. The demarcation of *kwin* boundaries, as well as of groves, gardens, religious grants, etc., had been ordered; but when the party arrived, the demarcation of only one township, 150 square miles in area, had been completed, a fairly accurate index of which was received from the Deputy Commissioner in December. A second township, about 100 square miles in area, was subsequently demarcated, but before this the traverse work had extended into other parts of the district; consequently the *thugyis* of villages were ordered to demarcate their own boundaries. This was done with 4-inch whitewashed wooden stakes. The boundaries thus marked off were surveyed, and will be tested by the Settlement officer. The want of maps giving the relative positions and names of villages caused some inconvenience and delay, but to have waited for them would have caused needless waste of time. The district sub-divisions had not been definitely settled when work commenced: it now consists of two subdivisions, which are again divided into five townships. The most northern one, Singain, had been demarcated, and round it the first main circuit was run: other main circuits were built up on this from time to time, till at length the entire level portion had been enclosed, and all *kwins* within, surveyed.

184. The total area of the district is about 1,100 square miles, of which 350 square miles form a wild, hilly tract, almost uninhabited, known as Ye Yaman, of which a reconnaissance suitable for military requirements alone was made. The remainder is level country, interspersed with isolated and groups of low

* Colonel Steel speaks in high praise of Mr. F. Grant, and of the way in which he supervised the work in Serail; he also commends Mr. O'Sullivan for his work in connection with the starting of the Chittagong survey under very difficult circumstances.

Mr. McHatton is also reported to have worked with his usual zeal, care, and ability. Messrs. Smart and Lee are mentioned as able and energetic officers.

Of the native assistants, Mr. Sarat Chunder Sen is said to give promise of turning out a good steady assistant; Ramji Lall, accountant and head writer, and sub-surveyors Hilaluddin, Latiffullah Khan, Dharnidhur Mookerjee, Hamid Hussein, Binda Lall, Shakhawat Hussein, and computers Anga Mathu, Abdul Gani, Kishnaji Mahadeo and Balwant Vishnu are specially mentioned for good hard work.

hills, which, being rocky and unculturable, have only been surveyed on the scale of 2 inches to the mile. The rest of the district, 550 square miles, has been cadastrally surveyed on the 16-inch scale in the usual manner. Across this level portion, from the south-eastern to the north-western limits of the district, is a broad belt of very rich rice land, irrigated by an extensive system of canals, carried from the Panlaung and Zawgyi rivers, which, after draining large areas in the Shan hills, bring down sufficient water at all seasons of the year to irrigate at least 500 square miles of country. From these canals run innumerable irrigation channels that intersect the country in all directions. Two and sometimes three crops a year are raised on those lands, the gross produce of which is often as high as R125 an acre in the year. So continuous is the supply of water, so small the rainfall, and so favourable the climate, that ploughing, reaping and sowing may be seen in progress simultaneously in contiguous fields throughout the year; each tenant letting the water on and off his own fields without the slightest reference to the seed-time and harvest of his neighbours. Along the river banks and main canals are extensive groves of mango, palmyra, betel-nut, and plantains, and numerous *pan* gardens, which add to the picturesqueness of the scenery, to the wealth of the inhabitants, and to the difficulties of survey, which last are not lessened by the *kwin* boundaries usually following the bush-covered irrigation channels, and the field surveyors having to wade knee-deep in mud and water across the rice fields and over the high *kazins* or banks that separate field from field. At first the sub-surveyors, being new to the country and in constant dread of dacoits, worked slowly and made every pretence for keeping near the camp, and by the time they discovered that their fears were groundless, severe fever prevailed and prostrated more than half the establishment. Throughout December, January and February, the number of daily sick often rose to 150 men, but after that, the hospitals cleared, and during the latter months of the season the bulk of the establishment enjoyed excellent health. The death-rate was very small; only 18 men died during the whole season, or 2 per cent. of the whole establishment; the deaths were generally caused by fever.

185. On either side of the irrigated lands the country is dry, and large portions are covered with bamboo and scrub; much of this, however, has at a former period been cultivated; and under the jungle the limits of former fields are still discernible over an extensive area, labour only being required to bring almost every acre of it under cultivation again. Even now there are several fair-sized villages in these tracts, the inhabitants raising large quantities of tomatoes, chillies, sesamum, and other crops. The average size of these fields is from two to three acres, and that of the rice fields about half an acre; yet the survey even of the large fields could not be rapidly done, as much jungle clearing was necessary.

186. The out-turn up to the close of April, when field parties in India are about to close work, was not satisfactory. To have stopped work then would have left a large tract bordering on the Shan hills to be taken up during the most unhealthy part of the year, *viz.*, November and December, which would also have entailed the labour of re-clearing all the survey traverse lines; moreover the Settlement establishment would probably have been brought to a standstill for want of village tracings before next field season. The intense heat of March and April had been followed by almost pleasant weather in May, and the *amins*, just recovering from sickness, were desirous of making more money. Under these circumstances, it was considered advisable to prolong the field season, and this was done till the entire area to be cadastrally surveyed was completed in July, when the party went into recess at Mandalay. On conclusion of the traverse work in Kyaukse, half of the sub-surveyors were moved into Mandalay, and the boundaries of 96 *kwins*, with intermediate lines, covering 173 square miles, were traversed, the plots of which are being prepared for next field season.

187. In Kyaukse, clay cylinders were embedded at all tri-junction stations of villages and at one station on all boundary lines radiating therefrom; also at salient points of boundaries and at all main circuit stations: the total number amounted to 9,500, giving an average of 18 per *kwin*. Arrangements are being made by the Settlement department for the preservation of these marks, and 2-inch plots of each *kwin* will be prepared, showing the stations so marked. In Mandalay, clay cylinders were embedded at every traverse station.

188. In the field, no record writing was done beyond the filling up of "reference lists" for the proper preparation of maps in office, and for statistics of cultivation, groves, and other particulars. The Settlement officer, on arrival in April, was immediately supplied with the tracings of 40 *kwins* and a few village area statements, so that no time might be lost in beginning settlement work. Other tracings and area statements were supplied monthly, and up to date the tracings of 304 *kwin* plans and 114 area statements have been made over to the Settlement officer. All field limits have been entered in sheets in firm lines in accordance with the wishes of the Director of Land Records; the limits of holdings and of groups are entered by the Settlement staff. If photo-zincographic blue prints are hereafter supplied, it will be easy to distinguish holding limits on one copy by inking them up in black, leaving field limits in blue; this will secure a permanent record of holdings as they stood at the time of settlement. Blue prints would also be better for showing future additions and partitions. If, hereafter, it is considered advisable for the survey staff to write records, as is done in the North-Western Provinces, Central Provinces and Bengal, there appears to be no reason why it could not be done efficiently, in the manner adopted in Bengal.

189. Hitherto no survey errors have been reported by the Settlement officer, and there has been no revision survey. This is probably due to the careful system of checking adopted; not only were check lines run by inspectors and European officers during the progress of the survey, but a field book *partal* was run across every village after completion. Altogether 575 linear miles of check survey were run on board plans, and 536 linear miles in field books.

190. As soon as field work commenced, efforts were made to secure Burmans for all branches of the work. The survey school held under the Deputy Commissioner's supervision, was visited at his request by the Deputy Superintendent, who personally aided in the instruction of several scholars in plane-table work, and afterwards assisted in the examination held under the orders of the local Government. Some of these scholars and others trained elsewhere were entertained, and after some changes, one Burman inspector and 15 *amins*, with a full complement of Burman measurers remained and worked till the end of the season. Their work, after the first month, was found very correct, but their progress was slow, as, in addition to a want of physical strength to enable them to compete with the North-Western Provinces *amins*, nothing would induce them to refrain from leaving their work *en masse* whenever a market, play, funeral, or other amusement was in progress in the neighbourhood. Their average out-turn was about half that of the North-Western Provinces' *amins*, who turn out about a square mile a month. As the pay of the four measurers with each *amin* is R40 a month, it follows that the cost of survey by Burmans is about R40 per square mile more than that by North-Western Provinces' men which, on an area of 600 square miles, is R24,000, whereas the cost of bringing 100 *amins* to and from Calcutta is only R2,700. It is intended during the coming season to attach two or three Burman *amins* to each Indian squad, in the hope that by example, they may be induced to work more steadily. A large number cannot be secured, as nearly all trained men find work in the cadastral surveys being carried on under the local Government, where they are paid by fixed salaries and not by contract, as is the custom in the Survey Department.

191. One Burman from the Executive Engineer's staff was taught and employed on theodolite work as a sub-surveyor. He did fairly well for a time, but as he subsequently deserted, when he heard that a warrant had been issued for his arrest on a charge of bribery some two years ago, it is needless to say any more about him. No others applied for sub-surveyor's posts, though offered R40 per mensem; the average pay and allowances of Indian sub-surveyors being about R30 per mensem. A few good office hands are still employed, and six are being trained to use the theodolite. As measurers, the common villagers did very well so long as they were near their own villages and had not to pay for their food, but they deserted as soon as this was impossible. It is, however, hoped that at least two men will be entertained from the villages for each *amin* during the coming season, and that the cost of bringing about 200 measurers from India will be saved.

192. When operations first commenced, there were daily rumours of dacoits, and portions of the country near the hills were haunted by the gang of Boh Kyaw

Zaw, but our parties were never interfered with. At first, the assistants on circuit had Military Police escorts; but subsequently, with the consent of the Government, these were relieved and five *khalásis* of each party were armed with carbines, which met all requirements. The native establishment was entirely unarmed. In no district has the Deputy Superintendent seen so little friction between the tenants and survey *employés*, between whom not a single disturbance occurred to his knowledge. This is largely to be attributed to the cordial support of the Deputy Commissioner and other civil officers, but also to the tact of the European assistants, who, placed at intervals, went much among the people and remedied all possible causes of discontent as far as possible.

193. During the month of April, an exploring expedition towards the Shan States of Baw, Yatzauk, etc., was arranged by the Deputy Commissioner, Captain Johnson, to gain a knowledge of the country immediately touching on Kyaukse, and to improve the relation with the chiefs. With a view to making a rough sketch of this country, and of ascertaining what villages and cultivation there might be in Ye Yaman, Mr. Scott accompanied this expedition for about a week, and then turned northwards into Ye Yaman. A short account of this work will be found under the head of Geographical Surveys.

194. The work which has been accomplished is shewn in the following statement:—

District.	Cadastral Survey.			District.	Traverse and other Surveys.				
					Traverse.			Area of Topo. Survey, 2" to mile in square miles.	Area of Reconnaissance Survey, in square miles.
	Number of villages.	Number of fields, &c.	Area in square miles.		Area in square miles.	Villages.	Sub-traverses.		
Kyaukse . . .	484	5,09,857	550	Kyaukse .	625	484	563	154	350
				Mandalay .	173	96	86	...	...

195. Owing to the late date of closing field work, the statistical tables are not yet ready for the whole district, but the estimate of cultivated and uncultivated tracts made from the actual statistics of 220 square miles give results which, when placed alongside of previous estimates, show the necessity there was for an accurate survey, thus:—

	Estimated with reference to Irrigation in 1886.	Administration Report, 1888-89.	Present Estimate.
	Sq. miles.	Sq. miles.	Sq. miles.
Actually cropped	42	202	300
Fallow and culturable	188	506	210
Village sites under water, &c. .	...	110	40
Unculturable waste			
Hills and Forest, excluding Ye Yaman .	...	128	200
Ye Yaman	...	...	350
TOTALS .	230	946	1,100

The total district area is approximately as follows:—

Cadastrally surveyed, 16 inches = 1 mile . .	550 square miles.
Topographically surveyed, 2-inch = 1 mile . .	150 ,,
Ye Yaman. (Reconnaissance)	350 ,,
Hills remaining for survey	50 ,,
Total .	1,100 square miles.

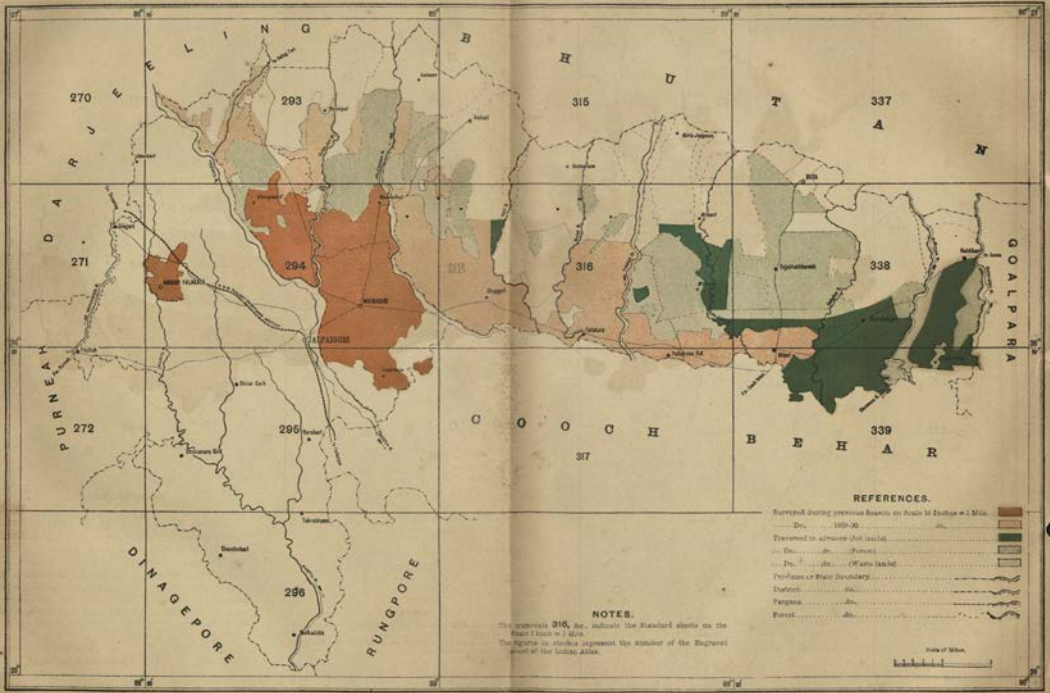
A general description of the district will be found in the appendix at page xlvi.

196. The cost of cadastral survey, 8 annas 5 pie per acre, is high, but it includes the cost of organization, the transport of equipment from Central Provinces, the permanent marking of stations, and the bulk of the demarcation. It is confidently expected that if funds sufficient for the survey of 600 to 700 square

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN THE WESTERN DOOARS (DISTRICT JALPAIGURI).

No. 4 PARTY.



REFERENCES.

Surveyed during previous Seasons on Scale 16 Inches = 1 Mile
Do. 1889-90 do.
Traversed in advance (Not inside) do.
Do. do. (Forest) do.
Do. do. (Waste land) do.
Provinces or State Boundary
District do.
Pargana do.
Forest do.

Scale of Miles.

NOTES.

The numerals 316, &c., indicate the Standard sheets on the Scale 1 Inch = 1 Mile.
The figures in circles represent the number of the Engraved sheet of the Indian Atlas.

Reg. No. 161, S. I. D.—9-6-90.—1,000.
Reg. No. 651, Imperial.—26-12-89.—750.
Photo. S. I. O., Calcutta.

miles annually are provided, the cost rate will be much reduced. But whatever the cost, it is almost a certainty that the increase of revenue will cover the cost of survey in two years at most, if not in one. The total revenue paid in 1888-89 was ₹2,45,126; this year the revenue paid is ₹5,09,901. This increase is doubtless due mostly to the settling down of this once much disturbed district, but it has been remarked that the advent of the survey alarmed the *thugyis*, and induced them to submit more accurate statements of the area under crop, lest the survey results should show startling discrepancies. Somewhat similar results may be confidently expected in every district to which the cadastral survey may extend.

197. To Mr. Scott's indomitable pluck and energy is due the successful completion of the survey of the Kyaukse district in the first season. His long experience in different countries and climates enabled him to cope with the various difficulties as they arose, difficulties which at one time almost stopped work; not the least of these were the severe outbreaks of fever which occurred at unexpected times; the men were mostly young and quickly gave in; their strength in many cases having been much reduced by semi-starvation owing to their desire to save money. Many would no doubt have succumbed but for the arrangements made by Mr. Scott, who had all sick men brought into the head-quarter's camp to ensure their receiving proper treatment; this was given them under Mr. Scott's personal supervision daily, and consisted to a great extent of the distribution of quantities of boiled milk with doses of quinine. The difficulties due to the nature of the country have already been briefly alluded to in paragraph 184, but this gives but little idea of the really trying nature of the work. In March, the local Government wrote expressing their appreciation of Mr. Scott's efforts, and giving him credit for the good progress made in the survey of the Kyaukse district.

198. During the next field season the cadastral survey of the district of Mandalay and the royal lands in Meiktila will be undertaken and it is hoped be completed.*

WESTERN DOOARS, BENGAL PRESIDENCY.

No. 4 Party.

199. This party was engaged during the year on the continuation of the survey of the Western Dooars. The recess office at Hazaribagh closed on the 3rd November 1889 and the field establishment assembled at Jalpaiguri on the 15th idem. Colonel Wilkins held charge of the party during the field season, and proceeded on privilege leave for three months from the 6th June, for which period the charge devolved on Mr. H. T. Hanby. On the return of Colonel Wilkins from leave on the 6th September 1890, he was transferred to the Head Quarter's Office and again made over charge to Mr. Hanby on the 8th September.

Personnel.

Colonel W. H. Wilkins, S. C., Officiating Deputy Superintendent, 1st grade, in charge from 6th November 1889 to 5th June 1890, and from 6th to 7th September 1890.
Mr. H. T. Hanby, Surveyor, 3rd grade, in charge from 1st October 1889 to 5th November 1889; from 6th June 1890 to 5th September 1890, and from 8th September 1890.
„ G. T. Hall, Assistant Surveyor, 1st grade, from 18th November 1889.
„ L. F. Berkeley, Assistant Surveyor, 1st grade.
„ W. E. Johnson, ditto ditto, 2nd grade.
„ C. G. S. Wood, ditto ditto, 3rd grade, from 15th November 1889.
32 sub-surveyors and others.

Temporary Establishment.

233 field surveyors, &c.

200. The divisions into which the lands of the Western Dooars are separated was explained in paragraph 141 of the Annual Report for 1888-89, and this is again given for easy reference:—

"The only territorial divisions bearing definite names in the Western Dooars are *parganas* and *talukas*; the latter are subdivided into plots of various sizes called *jots*, which are distinguished by the name of the tenant (*jotdar*) or of his successors and by serial numbers called *tauzi* numbers. The *taluka* is too large, and the *jot* too small, to serve as a survey unit, so it was decided to club several *jots* together, so as to make up areas approxi-

* Regarding the European assistants of the party, Mr. Scott writes as follows:—
"To the willing and cheerful manner in which the several European members of the party, *viz.*, Messrs. Price, Connor, Smart, Gastaud, Walsh and Baker, met the heavy demands on their services during a long and trying field season of nine months, and their cordial and friendly co-operation with each other, much of the success of the work must be attributed."
Of the Native assistants, Kedar Nath, computer, and Bhagobutty Charan Chuckerbutty, writer, are specially mentioned for reliable and intelligent work.

mating to the size of the *mausa* in the North-West Provinces and to treat them as the unit of survey, but the *jot* is the unit recognised for settlement purposes. These blocks of congregated *jots* are called *chaks*, which have been numbered consecutively for each *taluka*."

201. The traverse section completed, with the exception of some scattered *jots* and a detached *taluka* situated about 12 miles south of the boundary of the district, all the traversing necessary for the detail survey of the area originally allotted; but towards the end of the field season it was decided that the estate of the late Colonel Hidayat Ali should not, as was at first intended, be omitted, and this has added an area of 65 square miles for survey which will be undertaken during the ensuing season. In addition to the traversing above alluded to, the waste lands in *parganas* Moraghat, Lakhipur, West and East Madari, as well as a large portion of those in *parganas* Baksa, Phatibari and Bholka, were divided up into blocks. The boundaries of several large tracts of forest reserves were also traversed, sub-traverses being run across them when necessary; these latter were carried either along roads or compartment lines, and, when neither were to be found, were run east and west in parallel lines at about a mile apart.

202. The cadastral work of the remainder of the Mainaguri *tahsil* was completed, as was also that of the Talakata *tahsil*, with the exception of some scattered *jots*, and Colonel Hidayat Ali's estate since added to the programme of survey. In the Alipur *tahsil* the cadastral survey of *pargana* West Madari has been finished, but of about 40 square miles the village records still remain to be written; these will be taken up as soon field work is resumed in November.

203. The traverse and cadastral sections commenced field work during the last week of November 1889, and closed during the first fortnight of June 1890. The office establishment for completing the vernacular records was left at Jalpaiguri under Mr. W. E. Johnson, the separation of this portion of the office from that of the Settlement officer having been found very inconvenient during the previous year.

204. The tri-junctions of *chaks* were marked by prism-shaped stones, of which 1,450 were embedded; these, in addition to some large partially dressed stones, were put down by the Settlement Department; the exact number of these is not known. In addition to these tri-junction stones, a certain number of intermediate stations were marked with baked clay cylinders during the early part of the season, but latterly by overburnt bricks which, it is believed, will be better able to withstand the excessive moisture in the soil, besides being very much more easily transported.

205. The procedure laid down by the Settlement officer for dealing with disputed boundaries was found to work well, and the 61 disputes were easily disposed of. It was decided that that boundary which agreed most nearly with the old records should be adopted and that a tracing in duplicate of the whole locality should be sent to the Settlement officer with notes to assist him in his decision. If no objections were then raised as to the boundary, one copy was to be signed and returned to the Survey office for record, whilst the second was to be retained in the Settlement office.

206. The out-turn of the party is given in the following statement which shows the amount of traversing and cadastral area completed:—

Pargana.	Traverse Survey.		Cadastral Survey, 16 inches=1 mile.					Remarks.
	Number of *chaks* and blocks.	Area in square miles.	Number of *chaks*.	Number of *jots*.	Number of fields.	Number of *kiaris* (sub-divisions of fields).	Area in square miles.	
Chengmari I.	...	...	172	582	41,623	50,866	45·36	With record of rights.
North Mainaguri	...	...	189	1,031	47,240	35,288	45·44	
Lakhipur	...	...	38	85	8,061	3,848	7·04	
Moraghat	148	98·99	389	1,363	1,09,115	68,368	110·64	
West Madari	102	56·47	129	742	35,464	14,201	59·99	
East Madari			7	53	2,950	1,053	5·28	
Chakwakheti			1	12	235	44	0·98	
Bhatibari	268	320·70	...	...	...	...	...	
Baxa								
Bholka								
Forest Blocks	16	259·49	...	...	...	...	...	
Totals	534	735·65	925	3,868	2,44,668	1,73,668	274·73	

Pargana.	Traverse Survey.		Cadastral Survey, 16 inches=1 mile.					Remarks.
	Number of *chaks* and blocks.	Area in square miles.	Number of *chaks*.	Number of *jots*.	Number of fields.	Number of *kiaris* (sub-divisions of fields).	Area in square miles.	
Brought forward .	534	735·65	925	3,868	2,44,688	1,73,668	274·73	
Moraghat . .	...	...	48	...	39,097 (including *kiaris*.)	...	40·37	Surveyed only.
East Madari . .								
Chakwakheti . .								
Bhatibari . .								
Baxa . . .								
Grand Totals .	534	735·65	973	3,868	2,83,785	1,73,668	315·10	

The average size of the fields in the cadastral area is 0·72 of an acre, exclusive of the sub-divisions of the fields, which are called in the North-West Provinces *kiaris*, or 0·42 of an acre including them.

207. In the cultivation, the practice of showing by dotted lines the sub-divisions of the fields made for irrigation or other purposes has again been followed. The firm lines denote the limits of the fields proper, each of which bears its distinguishing number, and together with the dotted sub-divisions of the fields show how they appear on the spot, thus enabling any inspecting or revising officer to readily recognize on the map any particular locality from its appearance on the ground. The numbers of the fields are thus kept within reasonable limits, a most desirable result, which would not be the case if each small plot were separately numbered; thus there were 2,44,688 fields numbered, whilst there were 4,18,356 blocks surveyed as found on the ground. The dividing ridges of the fields and of their sub-divisions being all exactly alike, it is impossible for the surveyor to distinguish the one from the other; the division has therefore to be made when the records are being written up and all the cultivators are present; hence in that portion of the country which have been surveyed cadastrally, but of which the records have not yet been written, the number of blocks as they appear on the ground, and not the true number of fields, has been returned.

208. The cadastral survey was tested by 614 linear miles of check lines and the *khasra* entries of 84,340 fields were checked either by European officers or by the Native inspectors in charge of the squads.

209. The season's out-turn has been mapped on 845 sheets which cannot be finally disposed of or submitted for publication till the settlement has been effected. The completion of the sheets and the submission of the records to the Settlement Department have been much retarded owing to the necessity of comparing the boundaries of all the *jots* that had been surveyed up to date with those as given on the old 16-inch sheets of the last settlement and on the maps of the *jots* that have been allotted since then. These comparisons have shewn that in the jungly tracts large encroachments have been made since last settlement by some *jotdars*, and also that there are several *jots* in existence of which no trace can be found in the settlement records; from this it would appear probable that in some cases land is being, and for some time has been, held surreptitiously. The identification of every *jot* now in existence is very necessary to ensure that none are omitted from the present survey; this, however, in many cases has proved to be a matter of considerable difficulty, partly in consequence of the very faulty nature of the old maps and partly in consequence of the large encroachments on Government lands, which in one case amounted to as much as three times the area of the original *jot*. Such encroachments have of course entirely altered all the old boundaries, and it is most difficult now to recognize the position of the old *jots*, for there is nothing definite to start from on which to form a comparison between the old and the new surveys.

210. In order to permit of the forest reserves, waste lands, &c., being mapped in their true relative positions, and at the same time to locate and prevent the omission of any tract not yet surveyed, a series of 4-inch skeleton sheets

embracing the entire area has been prepared on which all the details will be surveyed, excluding only those portions which have been surveyed cadastrally.

211. To ensure as large a proportion as possible of the field records being written in the vernacular of the province instead of being first entered in Urdu by the North-West Provinces *amins* and afterwards translated into Bengali, as many *mohurrirs* as could be obtained in excess of the Bengali *amins* already employed were entertained and two survey schools, with Bengali inspectors as teachers, were established and placed under the supervision of the assistants in charge of field sections; the *mohurrirs* were then taught to read maps correctly, to rectify any local errors, to insert any omissions in survey, and lastly to write the record of rights unaided by the *amins*. The experiment proved fairly successful, and in a short time 23 out of the 31 men admitted proved themselves capable of working independently: by the individual training of a few others while work was in progress, three more were passed, thus obtaining 34 men in addition to the 44 Bengali *amins*.

212. The inhabitants were on the whole inimical to the survey and were very unwilling to help in any way, except under compulsion. Even the Deputy Commissioner admitted his inability to cope with the utter indifference of the *jotdars*, and it was only through the unflagging energy of Mr. Sunder, the Settlement officer, that the tardy aid of the native officials was eventually secured.

213. The general health of the party was as bad as it well could be throughout the greater part of the field season, notwithstanding the strenuous efforts made to ensure an early supply of medicine and a proper attendance on the sick. Several deaths amongst the *amins* and *khalásis* tended further to dispirit the rest. Hardly a man in the field escaped from the malarious fever and the assistants suffered more or less severely. The early advent of the heavy rains, in the first fortnight of June, added much to the sufferings of those who were already unwell, and many of those who were not prostrated by fever or dysentery were incapacitated for work by the leeches which made their appearance simultaneously with the first shower; some of the men were so badly bitten that they were unable to move about at all. During the hot weather, prior to the setting in of the rains, the difficulty in supplying water to the surveyors who were working in the forests was very great, and special measures had to be adopted to ensure that the supply was maintained regularly. The wild animals with which these forests abound added to the fears of the natives, and they had often to camp very far from the scene of their actual work, as fires in the forest reserves were forbidden and without them their lives would certainly have been endangered.

214. The causes above enumerated, together with the extra work entailed on the establishment by the carrying out of the procedure noted in para. 209, and the corrections and alterations rendered necessary thereby, have added much to the cost of the survey, details of which will be found in the tabular statement at page 84.

215. Early in April 1890, the field office of the party at Jalpaiguri was inspected by the Deputy Surveyor-General, who found every thing being carried on in as satisfactory a way as was possible, considering the great local difficulties the party had to contend with.

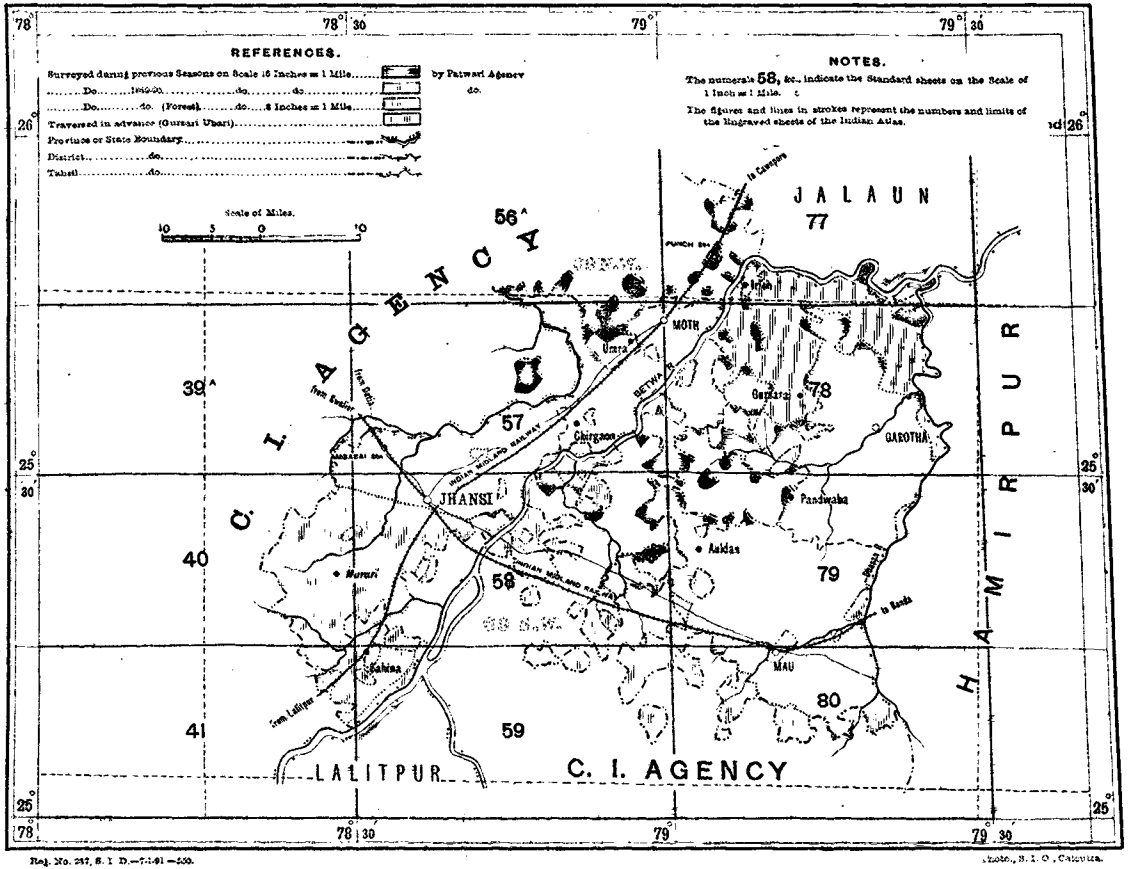
216. The work assigned to the party for the coming field season is the traversing of the remaining portion of the Dooars (exclusive of the tea lands already blocked out), in all about 396 square miles; the cadastral survey of about 188 square miles, including the estate of the late Colonel Hidayat Ali; the topographical survey of about 383 square miles of Government waste land, and the detail survey and classification of 448 square miles of forest land, both on the 4-inch scale. In addition to this the relaying of the boundary between Cooch Behar and the Dooars and the survey and demarcation of the Bhutan frontier have to be undertaken; this latter will include a small area of the hill tracts.*

*Amongst the European assistants, Messrs. G. T. Hall and L. F. Berkeley are specially mentioned by both Colonel Wilkins and Mr. Hanby. Mr. C. G. S. Wood is also noticed favourably. The following members of the native establishment are also commended, *viz.*, Mir Usjad Ali, Babu Jageswar Bhuttacharjee, Ramjas Misir, and Mahomed Ali, permanent hands, and Raj Bahadur, Kalyan Rai, Nawab Ali, Abdul Majid and Kanaya Lall, temporary hands.

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT JHANSI.

No. 5 PARTY.


REFERENCES.
Surveyed during previous Seasons on Scale 16 Inches = 1 Mile..... by Patwari Agency
.....Do.....1849-50.....do.....do.....do.....
.....Do.....do. (Forest).....do.....8 Inches = 1 Mile.....
Traversed in advance (Guzari Ubari).....
Province or State Boundary.....
District.....do.....
Tahsil.....do.....
NOTES.
The numerals 58, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.
The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.
Scale of Miles.
10 5 0 10
78°
78° 30
79°
79° 30
26°
25° 30
25°
JALAUN
77
56
C. I. AGENCY
HAMIRPUR
39
57
78
40
58
79
41
59
80
JHANSI
LALITPUR
C. I. AGENCY
MOTH
Umra
BETWA R.
Garautha
GAROTHA
Chirgaon
Pandwaha
Aaldas
Mauranipur
Mau
Rahina
Jhansi
Lalitpur
Indian Midland Railway
Bundelkhand Railway
Iron Bridge
Iron Bridge
Iron Bridge

NORTH-WEST PROVINCES.

No. 5 PARTY.

217. This party, of the strength shown in the margin, resumed its operations in the North-West Provinces. It was employed on cadastral surveys, including the writing of the record of rights, in Jhansi and Garhwal districts; on the cadastral survey of the Garhwal Bhábar estate, Tarai district, the Kumaun Bhábar, and also of the Rampur state. In the Jhansi district and in the Kumaun Bhábar, the forests were also surveyed, the former on the 8-inch and the latter on the 4-inch scale. In addition to the above, traverse surveys were carried on in the Lalitpur district and in the Gursarai estate, Jhansi district. Each of these operations will be reported on separately.

Personnel.

Lieutenant-Colonel J. E. Sandeman, S. C., Deputy Superintendent, 2nd grade, in charge.
Lieutenant R. T. Crichton, S. C., Assistant Superintendent, 2nd grade, from 16th December 1889.

Jhansi Cadastral Section.

Mr. T. F. Freeman, Assistant Surveyor, 1st grade.
„ N. Bedford „ „ 2nd „
16 inspectors.
10 *kanungos.*
283 *patwáris.*

Garhwal and Kumaun Bhábar Section.

Mr. J. Murphy, Assistant Surveyor, 1st grade.
„ W. V. Skilling, Assistant Surveyor, 1st grade.
13 inspectors.
26 *patwáris.*
6 estimators.
8 computers.
10 boundary surveyors.
142 *amins* (under instruction).

Rampur State Section.

Mr. A. W. Smart, Assistant Surveyor, 1st grade.
„ J. H. Murphy, „ „ 3rd „
12 inspectors.
101 *patwáris.*

Lalitpur Traverse Section.

Man Mohun Lal Agarwala, Assistant Surveyor, 3rd grade, from 20th October 1889 to 20th May 1890.
10 computers.
16 sub-surveyors.

Jhansi District.

218. The 16-inch cadastral survey of the Jhansi district, which was ordered in G. O. No. $\frac{88}{I.\ 508}$, dated 29th June 1888, and which had been for the most part completed in 1888-89, was continued during the season under report. The maps of the area of nearly 1,200 square miles previously surveyed having been brought up to date under section 21 of the Board's rules, the remaining area of 282 square miles was surveyed and then the *khasras* of the whole district were written. No traversing in the Jhansi district except what was done in the Gursarai estate was executed, it having been completed during the previous season. Field operations commenced on the 1st November 1889 and were continued until 11th May 1890.

219. The Deputy Superintendent inspected and checked the work in all four *tahsils* during November and December 1889, and satisfied himself that it was being done in all respects in the manner required. The area surveyed during the past season, which lay chiefly in the south of the Mau and Jhansi *tahsils*, is given in the accompanying table—

District.	Number of villages.	Number of fields.	Area in square miles.
Jhansi	138	132,310	282

The average size of the field during the past season is 1·36 acres. This season's survey has been mapped on 409 sheets. The check surveys aggregated 714 linear miles and 263,634 numbers in the *khasras*, or about 40 per cent.

The following statement gives according to *tahsils* or *parganas*, the total area, &c., of those portions of the district which have been cadastrally surveyed,

the village records of the whole of which were written during the year under report:—

Tahsils.	Number of villages.	Number of fields.	Area in acres.
Mau	170	177,830	273,654·0
Garotha	119	101,868	191,472·3
Jhansi	214	226,133	303,239·1
Moth	134	142,119	153,053·0
TOTALS	637	647,950	921,418·4 1,440 square miles.

The above area has been mapped on 1,609 cadastral sheets, and it does not include the area of the forests and of Gursarai estate, which have been traversed only. The recess office was held at Jhansi and was visited by the Deputy Superintendent in June.

220. The Jhansi district has been surveyed entirely by *patwári* agency under the Survey Department, which has held itself responsible for the professional accuracy of the work.

The cost since the commencement of operations is given below:—

Description of work.	1887-88.	1888-89.	1889-90.	Total.
	R	R	R	R
Traverse survey	9,895	8,363	...	18,258
16-inch field survey	...	27,718	9,436	37,154
Records	...	...	22,362	22,362
TOTALS	9,895	36,081	31,798	77,774

The rates derived from the above for the whole district are—

	R	a.	p.	
Traverse survey	12	10	10	per square mile.
Field survey Record writing	41	4	8	„ „ „

or a total rate of R53-15-6 per square mile, inclusive of all charges, imperial and provincial.

Lieutenant-Colonel Sandeman undertook to do the work, if he were allowed the services of the district staff, at a rate all over of R40 per square mile, on the condition that the unit of area of supervision in any one locality was not less than 2,000 square miles. He points out that, as the operations were restricted to 1,440 square miles, this in itself is sufficient to account for the somewhat higher rate, not to mention some minor conditions which were not fulfilled. For instance, in many *patwáris'* circles the area in excess of the normal is so great that it was manifestly impossible for those officials to survey it unaided; the survey had therefore to be partly executed by paid *amins*, which has somewhat raised the rate. Moreover, Jhansi is an unusually difficult district in which to begin a new system with *patwári* agency which, unfortunately, proved to be much below the average in quality. The numbers of *kanungos*, *patwáris*, &c., who are now qualified as surveyors of various degrees of skill are, *kanungos* 11, *patwáris* 239, *umedwars* 35. Two years ago, these men were entirely ignorant of all survey matters. There are still 48 incompetent men of whom a list has been supplied to the Settlement officer. Survey certificates have been given to all *patwáris* who are skilful surveyors.

221. There were only 86 boundary disputes brought to notice, of which 36 were amicably settled at the time of survey, by reference to the old maps. The triple junction pillars in the district are in very bad repair; the Settlement officer intends to place cut stones at these points. Many of the *chiras* (flagstones) of the old settlement are still standing, especially in the Moth and

Jhansi *parganas*, and where these are wanting every endeavour has been made during the survey to make the *zamindars* replace them. The theodolite stations are either on boundary *chiras* or are marked by uncut stones let into the ground, with a cross or a triangle cut on them. Receipts have been taken from the *zamindars* for these important reference marks. Government has acquired proprietory rights in many villages, and every endeavour has been made to correctly record these *nazul* lands which are partitioned, but not demarcated in any way on the ground. The Indian Midland Railway authorities failed to mark the limits of the Manikpur line, and what has been surveyed on this branch, as on the others, Gwalior, Itarsi, and Cawnpore, which are fenced, does not agree with the maps in the possession of the Railway authorities.

222. Duplicate tracings of the village maps, *khasras*, *jamabandis*, &c., according to the Board's rules have been made over to the Settlement officer. The statistics comprise those of soils, irrigation crops, ploughs, cattle, wells, &c.

223. The Deputy Superintendent remarks that the task he had undertaken at first looked quite hopeless. Had it not been for the assistance rendered by the Settlement officer he believes that the survey would never have been completed, for the strict rules and supervision of the Survey Department and the continued effort and minute accuracy required from the *patwari* are most distasteful to him. The advantages of a system, in which the division of labour is such as to prevent waste of power and to utilize to the utmost the skill and experience of experts, both of the Survey and Revenue Department, have been now clearly demonstrated, and to Colonel Sandeman's energy and perseverance the successful results of the Jhansi survey are due.

224. The survey of the forests in the Jhansi district on the scale of 8 inches = 1 mile was sanctioned in Government order No. $\frac{745 \text{ F.}}{902-7}$ Revenue (Forest) Department, dated 20th February 1889, to the address of the Board. The only existing maps of these forests were very rough boundary maps on which the demarcation pillars were not shewn, as they were erected subsequent to the survey; the Conservator declared these maps, owing to changes of boundaries in many instances, to be entirely useless. There are 67 plots of *acacia arabica* in the Moth *pargana* which were surveyed in season 1888-89 on the 16-inch scale as forming portion of the *mauzas* amongst which they are scattered. The following tabular statement shews the area of the forests in Jhansi district, which, with the exception just quoted, have been surveyed on the 8-inch scale during the season under report:—

Parganas.	Number of Forests.	Number of villages in which situated.	Scale.	Area in acres.	Area in square miles.	Remarks.
Moth	65	62	16-inch	1,001·58	3·05	Eight of these are grass *runds*.
Do.	8	6	8-inch	950·38		
Jhansi	67	31	Do.	15,212·41	23·77	
Mau	13	9	Do.	6,924·59	10·81	
Garotha	9	8	Do.	6,512·97	10·18	
Totals	162	116	...	...	47·81	

The grass *runds* which are included in the forest area have also been declared as reserves or are about to be so declared.

225. In accordance with the directions of the Conservator of Forests, Central Circle, the forests have been classified as (1) teak, (2) bamboos, (3) teak and bamboos, and (4) mixed forest. A register has been prepared of each forest in which the details of area, soil, forest growth, &c., are given under the number of each separate item. As the demarcation of the forest boundaries and settlement of disputes was proceeding at the time of survey, many re-surveys had to be made. Now the boundaries have been marked by stone or masonry pillars at all bends, except in the small forests in Moth *pargana*, the limits of which are shewn by *chiras* (flag-stones) or by deep ditches. All pillars and stones have been mapped. In some forests, scattered patches of revenue-paying village cultivation are found within the forest limits.

226. The following is a statement of the expenditure on the forest survey in the Jhansi district during both seasons:—

Season.	Cost.	Total.	Area in square mile.	Rate per square mile.
	R a. p.	R a. p.		R a. p.
1888-89	751 0 0	...	...	...
1889-90	1,797 8 3	2,548 8 3	47·81	53 4 8

227. The following Assistant Magistrates went through a two months' course of instruction in surveying in the Jhansi district:—

Messrs. R. Greeven, B.A.B. Chapman, P. U. Allen, F. J. Pert, H. W. Lyle, T. C. Piggott, H. Spencer, Agha Abu and Turab Khan.

Garhwal District.

228. The orders for the prosecution of the cadastral survey of Garhwal are contained in General order No. $\frac{26C}{164R}$, dated 10th December 1889. A small staff of traverse surveyors was organised from the Lalitpur and Kumaun Bhábar establishments, the men being placed under Mr. W. V. Skilling, as no more experienced officer was available. Owing to orders for the survey being received so late, a sufficiency of instruments was wanting. Owing to the mountainous nature of the country, measurements with the chain were impracticable and the subtense bar method of traversing was adopted. Some subtense bars were made up, but then, no less than 4 of the sub-surveyors failed from various causes immediately after they had begun work, and hill-men had to be trained, whose work in many instances afterwards proved unsatisfactory. The traverse survey runs between 60 of the trigonometrical stations of the topographical survey of Garhwal, the distances of the traverse lines being obtained by the measurement of the horizontal angle subtended by a bar of 10 feet length; for this purpose, 15 repetitions of the subtended angle were taken as a rule, for it was found by experiment beforehand, that this number gave good results for short distances. The cultivated area of 565 villages has been covered with 6,660 traverse stations fixed within it. The area of this cultivation is not known, but the whole area covered by the operations after deductions for bad work is about 300 square miles. The initial bearings and co-ordinate values of the stations have been derived from the old triangulation data and no astronomical observations have been necessary. The work covers portions of four square degrees, the centres of which are the origins for all the traverses lying within each degree. Theodolite observations have been taken at 6,660 stations, and at these either rocks *in situ* have been marked with a triangle or stones have first been embedded and then marked. In every instance a pile of stones has been placed over the station for its more ready identification. The expenditure on the traverse survey has been R12,244-10-7 which gives a rate of R40-13 per square mile over all, but this rate will decrease as the work proceeds. The Deputy Superintendent made an inspection of the traverse establishment in the field in March.

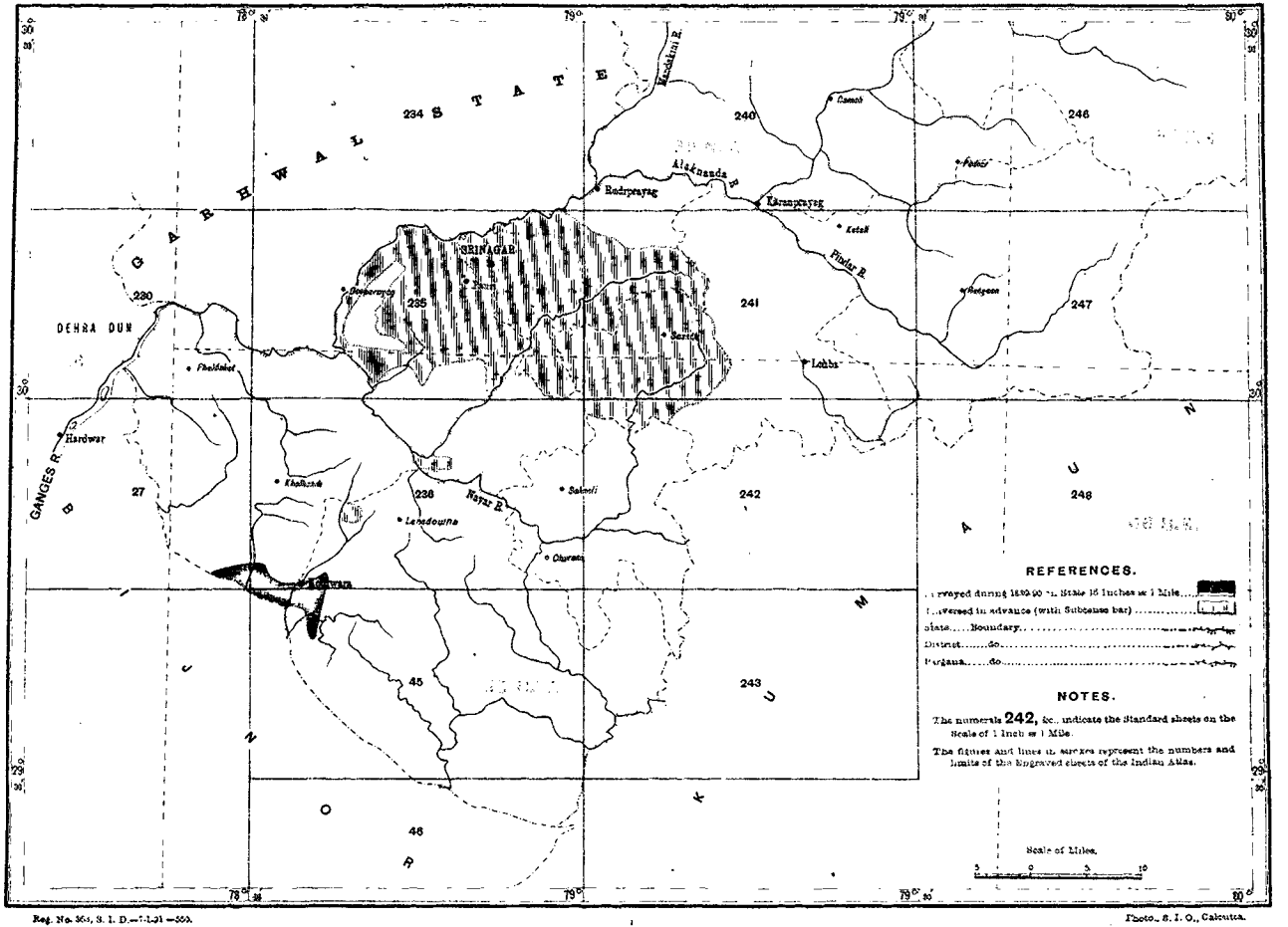
229. Towards the end of October 1889, Colonel Sandeman, anticipating the orders for the prosecution of the survey, proceeded to Garhwal and arranged with the senior Assistant Commissioner for an establishment of hill *amins* and *patwáris* who were to be sent for instruction to Ramnagar, the headquarters of the survey detachment in Kumaun. The men, to the number of about 150, of whom only 20 were *patwáris*, joined during November and December 1889, and were instructed in plotting and field surveying.

230. The Deputy Superintendent on his arrival at Ramnagar early in January 1890, removed the men to the Garhwal Bhábar estate, a small tract of cultivation, 10,240 acres in area and containing 56 villages of which the survey had in the meantime been ordered. Here they were made to survey in batches of from four to six, each man taking his turn to do a portion. At the end of February, the new establishment, having accomplished the survey of the Bhábar estate in a creditable manner, was moved up to the hill villages. Here, however, difficulties began to arise; the Deputy Superintendent, on making a round of inspection of all the squads, found famine, of which there had been no previous warning, im-

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT GARHWAL.

No. 5 PARTY.



Reg. No. 364, S. I. D.—7-1-91—550.

Photo., S. I. O., Calcutta.

pending in the Talla Salan, Chaund-Kot, and southern portion of Barasyun *parganas*; in consequence of this, he had to move many of the squads further north after they had received their plots and begun work. The plots of some of the new villages to which they were sent were not ready, and the men had been also discouraged by having to leave work unfinished and to begin a second time. He was then, about the end of March, obliged to leave Garhwal, and until Mr. Murphy's arrival on 23rd April, after the completion of the Kumaun Bhábar survey, there was only a young inexperienced assistant present, who did not treat the men very judiciously. The result was that the hill-men with whom the system of survey under strict professional supervision was unpopular, became insubordinate to the inspectors and finally struck work. They were apparently encouraged in this by the local officials who were all hill-men and all landholders, for on the arrival of Colonel Sandeman at Pauri on 4th May, the establishment not only refused to return to work, but induced 30 or 40 of those who had continued working up to that date to resign; some of these men confessed that the pressure brought to bear on them by their brethren was too much for them and they could not continue to work. The senior Assistant Commissioner who was absent in the plains, was then ordered up to make an enquiry; the result of this was that some of the local officials were punished. Thus this attempt to make a survey with local agency was frustrated, for most of the twenty *patwáris*, who had been instructed, had been withdrawn for famine purposes and there has been practically no return for the money spent in training the men and in the pay of their chainmen. If they had given themselves the chance of gaining some experience their services might have been advantageously utilized hereafter, for it is not intended to entirely exclude them, as it is believed that they were mismanaged and were almost certainly led astray by designing and disloyal officials. After the establishment struck work, a small area of 1,300 acres in the immediate vicinity of Pauri was surveyed through the agency of the inspectors, and the records of this area, which contains 10,200 fields, were written, the object being partly to show the people that the survey is possible, and partly to ascertain for future guidance what the difficulties of the work may be. In this experiment the physical difficulties of the survey have been overcome and the progress has been at the rate of five to seven acres a day, and the only thing now to prevent a fair rate of progress with an efficient establishment is the small size of the field; this can hardly get smaller, and there is every reason to expect an increase in size, if not in Barasyun, at any rate in some of the other *parganas*, where the population is less dense and the cultivation is of more recent date.

231. A sum of ₹8,235, inclusive of all supervising charges, has been spent on the Garhwal survey, but this money will probably not be entirely thrown away, as it is believed that the services of most of the trained men will be eventually utilized. The resumption of survey operations has been ordered by the Local Government in G. O. No. $\frac{14-41A}{1-556}$, dated 23rd August 1890, the people of Garhwal having been warned that opposition will not be tolerated. Sanction has also been given to the employment of a mixed establishment of trained surveyors from the plains and hill-men; this will of course necessitate an increased expenditure. The original estimate was a comparatively low one as it was based on the supposition that the survey would be made on the plan which has been so successfully adopted in the Tarai and later in Jhansi by *patwári* agency; in Garhwal, however, assistance from the local *madadgars* would have been necessary on account of the paucity of *patwáris* there. The scale of the Garhwal maps is to be 32-inches to the mile, to be increased at the discretion of the Deputy Superintendent. The Government has ruled that the village boundaries are not to be demarcated, but that their description is to be transferred to the new maps from the *chaknámas* of the old settlement. This in many instances is found to be so vague that the plan, as originally proposed, of marking the boundaries from their description on the topographical maps cannot be carried out. A map is being prepared on the 4-inch scale of each *patti*, on which will be plotted all theodolite stations, and on which the blocks of cultivation of each *mauza* will be shewn in their true relative positions; this map will serve as an index to the cadastral records. On the maps of the old settlement, the relative positions of different patches of cultivation to each other is at best only roughly preserved, and in the cases where they are really far apart, they are shewn as being close together on the map.

232. The assessable area returned at the last settlement was about 235 square miles. Colonel Sandeman's estimate is that it is probably not less than 800, but as this is based only on what he has seen in the lower *parganas* and from hearsay in those to the north, it is quite possible that he may be mistaken. So far, in 18 of the villages which have been surveyed up to date, a comparison roughly made gives an increase of 93 per cent. over and above the reputed area, and this increase is obtained round Pauri where there is comparatively little new cultivation.

233. During the recess, rules have been promulgated by the Board for the conduct of the survey and the preparation of the village papers. The rules in detail for the guidance of the surveyors drawn up by the Deputy Superintendent in consultation with the Commissioner and District Officer under the Board's rules, cover all the peculiarities of tenure and cultivation of the country. Measures have been adopted to check attempts at concealment of cultivation.

Garhwal Bhábar Estate.

234. The survey of this estate was ordered by G. O. No. $\frac{1360}{XB-170}$, dated 27th February 1890, at a cost of ₹650 to the end of 30th September 1890. It was traversed *mauzawar* during November and December 1889 by some surveyors under Mr. W. V. Skilling who became available from the Kumaun Bhábar.

235. The estate which belongs to Government lies in the forests at the foot of the Garhwal hills, extending from Sanai on the east, to Haldu Khata on the west. It contains 51 villages in this main tract and 5 detached villages to the extreme east of Garhwal, near Ramnagar. The area of the estate is about 10,240 acres or 16 square miles, and the whole was traversed. This is the tract which, as already stated, was used as a training ground for the Garhwal survey establishment.

One azimuth observation was taken and one connection made with a Great Trigonometrical Survey station, but further connections have still to be made on the extreme east and west. This will be done when the Garhwal traverse survey from the north approaches these villages.

236. The cadastral survey of the same area was completed and has been *partalled* by 72⅓ miles of check survey: it has so far proved good, but the late rains having done some damage in sweeping away portions, it is intended to bring the maps up to date and to re-check them before the *khasras* are written by the *patwáris*.

237. The senior Assistant Commissioner's advice and assistance in all matters connected with the survey are acknowledged by the Deputy Superintendent.

Tarai District.

238. An expenditure of ₹3,500 was sanctioned for survey purposes in the Tarai district by G. O. No. $\frac{6583}{X-907}$, dated 13th November 1889.

239. The Superintendent of the district desired Colonel Sandeman to arrange for the re-survey, on the 16-inch scale, of 24 villages in *pargana* Bazpur and 27 villages in *pargana* Nanakmata, which had some years previously been surveyed on the 4-inch scale by this department. Mr. Murphy who was working in the adjoining Kumaun Bhábar supervised the survey. Two *munsarims* were put in charge, one in each *pargana*, but the establishment consisted of 16 of the *patwáris* trained in previous seasons and the work was based on the old 4-inch traverse survey stations (which were found permanently marked) re-plotted on sheets on the 16-inch scale.

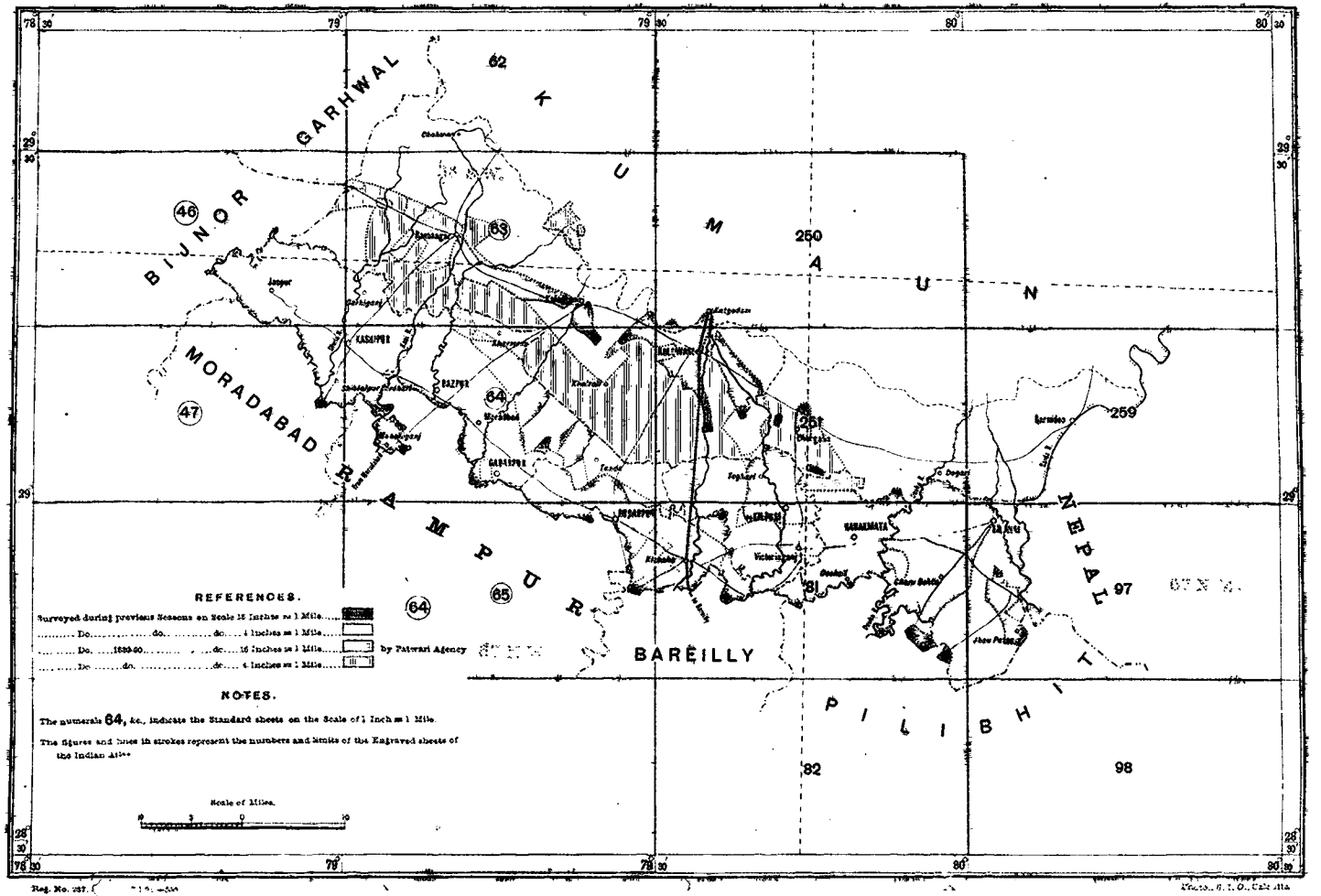
240. The statement of work accomplished in this way is as follows :—

Parganas.	No. of Villages.	No. of fields.	Area.	
			Acres.	Square miles.
Nanakmata	27	3,500	20,727·42	32·39
Bazpur	24	2,500	13,428·60	20·98
Total .	51	6,000	34,156·02	53·37

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. TARAI AND THE BHABAR OF DIST. KUMAUN.

No. 5 PARTY.



Reg. No. 257.

241. The average size of the field is 5·69 acres; this large size is due to considerable areas of waste land. The check survey amounts to 121·4 linear miles or 2·3 per square mile of area surveyed; the work proved good. The mapping is contained in 77 sheets. Copies of the cadastral sheets and of the area statements have been supplied to the district authorities. The cost inclusive of share of Deputy Superintendent's supervision, &c., has been ₹2,005-13-7, and the rate is therefore ₹37-9-1 per square mile, or ₹0-0-11 per acre.

242. The whole of the Tarai district has thus been surveyed cadastrally on the 16-inch scale, except the forests (fuel and fodder reserves) which have been surveyed and mapped on the 4-inch scale. The operations have extended over the last nine years, only scattered portions having been surveyed at a time; one *pargana*, Kashipur, was surveyed in 1873-75, when it formed a portion of the Moradabad district.

The following statement gives the total area of the district:—

District.	Number of Villages.	Number of Forest Reserves.	Area in square miles.
Tarai	637	...	709·29
	...	13	271·27
Total .	637	13	980·56

All the forest reserves except those in *pargana* Kashipur are district forests.

243. Topographical maps of the district have been prepared on fourteen standard-sized sheets, on the 2-inch scale, for reduction to one-half. Tracings of those 2-inch sheets have been given to the District Officer.

244. During the past season, there has been proof that many of the streams in the Tarai which have very shallow beds are in the habit of changing their courses considerably, and there is no doubt the very heavy rains and floods during the last monsoon have swept away and altered the topography of a good deal of what has been surveyed.

245. The late Superintendent, Mr. J. C. Macdonald, only lived to see the completion of the work in which he took a great interest. His death is deeply regretted by those who had the privilege of working with him.

The Kumaun Bhábar.

246. The continuation of the Kumaun Bhábar survey was sanctioned in G. O. No. $\frac{1540}{1-444 A}$, dated 14th October 1889, a sum of ₹8,100 being estimated as the cost of the traverse survey of the district forests. Operations were commenced on 15th November 1889. Angles have been observed with the theodolite at 2,102 stations, and mark stones have been embedded at 2,053 stations, the linear miles of new chaining amount to 316. The traverses connect the Tarai survey with the Kumaun triangulation, the geographical values of the latter being adopted as true elements of correction.

247. The following statement gives the out-turn of cadastral work chiefly on the 16-inch, but some of which is on the 32-inch scale:—

Number of Villages.	Number of Fields.	Area.	
		Acres.	Square miles.
149	30,196	27,922	43·63

The above villages have been mapped on 120 sheets. The cadastral survey has cost ₹4,113-13-3, which is at a rate of ₹94-4-3 per square mile or 0-2-4 per acre and 0-2-2 per field. The average size of the field is 0·92 acres. The check surveys aggregate 215 linear miles, giving an average of 4·93 linear miles per square mile. Colonel Sandeman inspected the survey in the Bhábar in January and again in April 1890, and personally *partalled* some of the cadastral survey which he found good in quality. The establishment consisted of 1 inspector, 5

amins and 10 *patwáris*. The *amins* were employed, as the District Officer could not spare enough *patwáris*.

248. It is believed that a few villages of insignificant area remain unsurveyed on the extreme east of the Bhábar, but these have been omitted by desire of the officer in charge of the Bhábar. Tracings of the cadastral maps and the registers of the areas have been supplied to the district authorities as usual.

249. In addition to the cadastral operations, a survey of the district forests was made on the 4-inch scale. The area of these is approximately 300 square miles. The forests are not demarcated but the theodolite mark-stones might be made to serve as demarcation pillars and thus would become doubly useful. The Government forest reserve pillars, wherever the district forests march with them, have been adopted as theodolite stations; a close connection has thus been made between the two surveys.

250. The forests were surveyed in small pieces and are being mapped on 37 quarter sheets, $3\frac{3}{4}'$ latitude × $7\frac{1}{2}'$ longitude, on to which also will be transferred the reserve forests from the maps of the Forest Department; the cultivated tracts will also be shown on these sheets, which will then serve as general maps of the Bhábar, as well as forest maps and they will furnish the materials for the 1-inch standard sheets. Tracings have still to be made for the District Officer, and the registers of areas and forest growth remain to be compiled. Portions of each plane-table were re-surveyed as checks and 30 linear miles of check survey were also run. The cost of the detail of the forest survey, inclusive of share of superintendence has been R13,367-2-4 which gives a rate of R44-8-10 per square mile. The Deputy Superintendent inspected some of the work in the field in April.

Rampur State.

251. The proposal of the Council of Regency was that that portion of the State granted by the Government after the mutiny, and which had been recently settled, should not be surveyed, but that a correct record of rights should be prepared of the rest of the State with a view to equitable assessment.

252. The local Government approved of the proposal in G. O. No. $\frac{607}{IV-503}$, dated 12th October 1889, to the address of the Agent to the Lieutenant-Governor for Rampur, and the Government of India sanctioned the survey in letter No. $\frac{21C}{8855}$, dated 10th December 1889, Revenue and Agricultural Department, to the Surveyor-General of India.

253. As the operations in Lalitpur came to a close, the traverse section was transferred therefrom to the Rampur State, and by the close of the season in May 1890, 13 main traverse circuits, enclosing 783 village polygons, were run; the latter were further divided by 963 sub-traverses, the area covered being 577 square miles. The theodolite was set up at 15,624 stations between which the chaining amounts to 2,728 linear miles. Clay cylinders were embedded at 12,315 stations. The Council preferred using these as permanent marks rather than stones which it had been intended should be obtained from the foot of the hills. The importance of covering the cylinders over with mounds of earth for their better preservation has been explained to the Council. The traverse survey of the State will be completed by January 1891.

254. The Deputy Superintendent visited Rampur early in January 1890, and in consultation with the Vice-President and Revenue Member of Council arranged the preliminaries for the survey. He had to weed out the *patwáris* as many old and decrepit men had been placed at the disposal of the inspectors by the *sadr kanungo* of the State.

255. Until Mr. Smart's arrival at the end of the month, the progress in instruction was not great. But eventually about 100 *patwáris* qualified and were set to work, and before the close of the season they had completed the amount of work shown in the accompanying statement:—

Number of Villages.	Number of Fields.	AREA.	
		Acres.	Square miles
101	49,716	42,240	66

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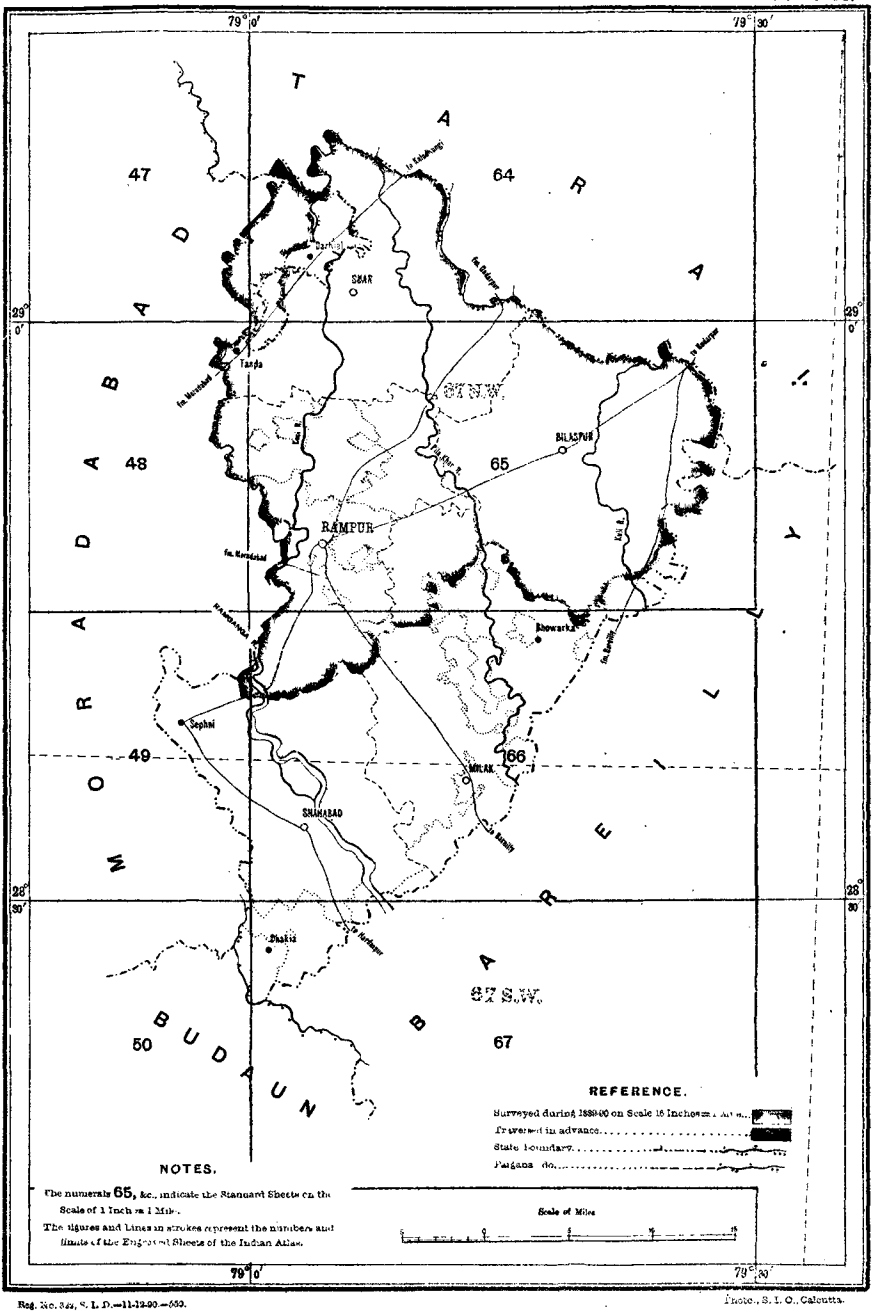
INDEX TO THE CADASTRAL SURVEY IN THE RAMPUR STATE.

No. 5 PARTY.



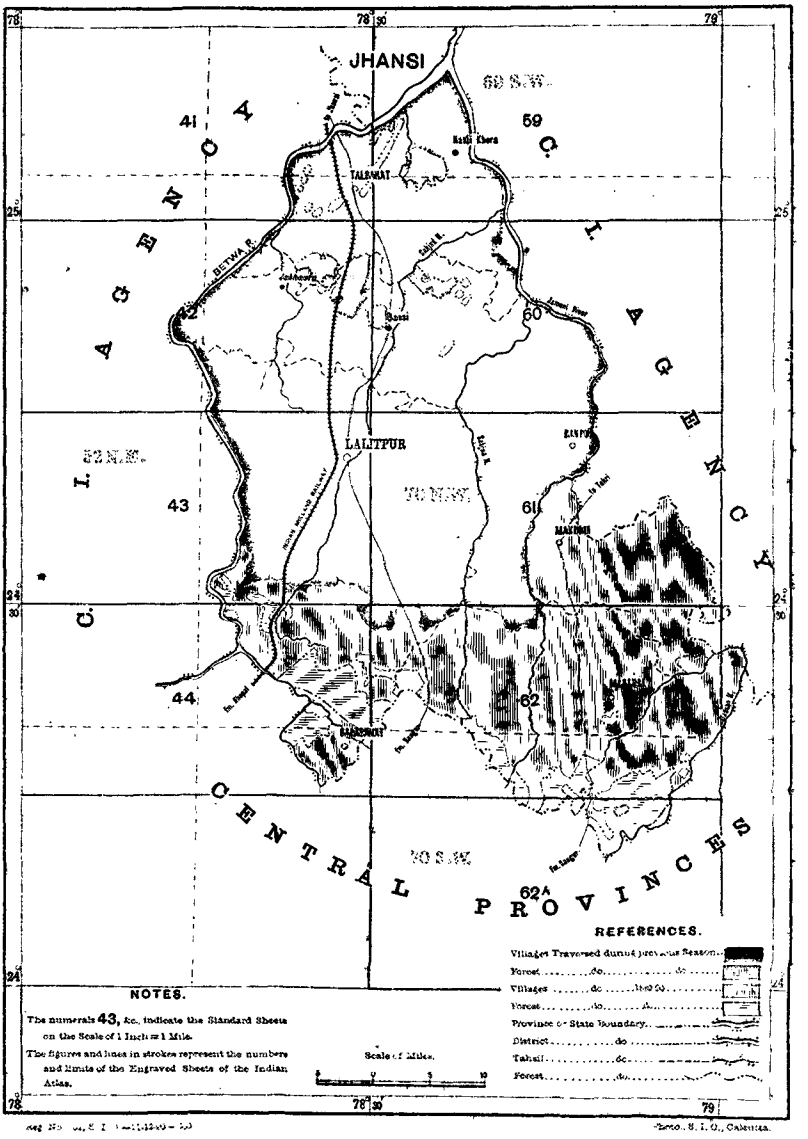
Reg. No. 342, S. L. D.—11-12-90.—550.

Photo., S. I. O., Calcutta.

NORTH WEST PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICT LALITPUR.

No. 5 PARTY.


JHANSI
LALITPUR
TALBAHAT
Basai
Rakh Khera
BETWA R.
Jakhaura
Sajnai
Sajnai R.
Lohari R.
Lohari
Rajghat
Rajghat R.
Jhansi Road
Jhansi-Midland Railway
Lalitpur R.
Lalitpur
Rajpur
Rajpur R.
Rajpur Tal
Mahroni
Mahroni R.
Mahroni Tal
Jamni R.
Jamni Tal
Lalitpur R.
Lalitpur Tal
Lalitpur Tal
Lalitpur Tal

The average size of the field is 0·87 acres. The scale of survey is 16 inches=1 mile, and the work which has been mapped on 122 sheets proved on *partal* to be first class. The check surveys amounted to 401 linear miles, giving an average of 6·08 linear miles per square mile of area completed.

256. During the recess, the training of *patwáris* has been continued, and the expectation is that over 200 men will be available for the survey of the rest of the State, which according to agreement must be completed by October 1891. The Assistant Surveyor in charge has been directed to employ a few *amins* if necessary, but to do so only in consultation with the Council of Regency. Some simple rules for the writing of the records have been drawn up which have been printed after approval and correction by the Vice-President and Revenue Member.

257. To prevent any attempt at encroachment on the villages of the adjoining British districts or *vice-versâ*, tracings have been made from the Settlement maps of Moradabad, Bareilly, and the Tarai for comparison with the boundaries as newly surveyed. Whenever it is found that possession overlaps or is claimed to overlap the last settlement boundaries of these districts, the cases will be brought to the notice of the authorities on both sides. The matter is a little awkward in the case of the Bareilly district where the survey was not a professional one, and of which the maps are not exact enough for the absolute transfer of boundaries. The area of the whole State is about 900 square miles, of which about 150 square miles are *jadid ilaqua*, and not under survey as previously explained. The future programme is to complete the rest of the State, containing about 1,300 villages, by 30th September 1891, almost entirely through the agency of the *patwáris*. The State will thus permanently benefit by the professional education given to its village revenue officials.

258. The courtesy of the President, the Nawab Safdar Ali, is acknowledged, and also that of the Vice-President, General Azimudin, Khan Bahadur; Mr. Wright, the Chief Engineer, and the Revenue Member, Mr. Ali Hussein, are stated to have aided the survey officials throughout.

Lalitpur District and Gursarai Estate (Jhansi District).

259. The traverse operations in the Lalitpur district, the orders for which were received with Board's No. $\frac{499}{1}$, dated 28th November 1888, were continued during the past season. In addition, the traverse survey of the Gursarai estate was carried out; this was ordered to be undertaken in G. O. No. $\frac{1621}{1-505}$, dated 9th November 1888, but it had been deferred because no arrangements had been made for the proper preservation of the stations. The Deputy Superintendent met Mr. Smart who was given the immediate superintendence of the work by appointment in the south of the Jhansi district, and after future plans had been discussed, Mr. Smart returned to Lalitpur and the Deputy Superintendent marched through the Gursarai estate inspecting the traverse survey there.

260. The following table shows the amount of work completed:—

Names of Districts.	Number of Villages.	Number of Forest Reserves.	Area.	
			Acres.	Square miles.
Lalitpur	309	34	404,854	632·6
	...	...	67,581	105·6
Gursarai	57	...	86,287	134·8
Totals	366	34	658,722	873·0

261. As the traverse survey of the Lalitpur district has now been completed the area, cost and rates for the whole district can be given. They are as follows:—

Nature of Work.	Cost.	Area in square miles.	Rate per square miles.
	₹		₹ a. p.
Village Traverse	30,260 3 4	1,800 58	16 12 10
Forest ditto	3,762 0 0	138·59	27 2 4

262. There are 36,472 permanently marked stations consisting of unhewn stones marked with a triangle or with a cross and *chiras* (boundary flag-stones) and platforms.

The mean variation of the needle in the district is E. 2°-11′-37″. Rough index maps of the theodolite stations are under preparation for the District Officer, who has promised to insist on the preservation of the stones. He has invariably afforded every assistance to the surveyors.

263. Lieutenant Crichton has been under instruction throughout the season. He did some triangulation in Jhansi, some traverse survey and azimuth observations in Rampur, and has gone through all the computations connected with the same. There is every reason to believe he will prove a competent survey officer. Experience he can only acquire by degrees.*

SIBSAGAR DISTRICT, ASSAM.

No. 6 Party.

264. This party resumed cadastral operations in the Sibsagar district on the 10th November 1889. Field work was carried on till the 15th May 1890, when the office establishment returned to recess quarters at Shillong.

Personnel.

Mr. E. C. Barrett, Deputy Superintendent, 3rd grade, in charge.
„ J. H. O'Donel, Surveyor, 3rd grade.
„ C. W. Wilson, Assistant Surveyor, 1st grade.
„ J. Smith, Assistant Surveyor, 2nd grade.
23 sub-surveyors and others.

Temporary Establishment.

171 field surveyors, &c.

265. The traverse survey was carried out in districts Sibsagar and Nowgong. The country was sub-divided into village blocks averaging a little over a square mile, due regard being paid to the boundaries of *mauzas* and estates which were upheld. Villages were as a rule sub-divided by sub-traverse lines with a view to facilitate the detail survey.

266. Cadastral survey was carried on in the same manner as during previous years by imported and local field surveyors, a much larger number of the latter having been employed during the year under report, the proportion being 5 local to 1 imported. The village headmen (*mandals*), candidates, and others, who had been sent to the survey camp at Jorhat from the several districts of the Assam Valley for this work, received instruction in practical surveying for about six weeks before actual work was started. The local men were exclusively employed in the field-to-field survey, and the imported men almost as exclusively in the survey of grants. The Hindustani *amins* were accompanied by Bengali writers called Deputy *mandals*, who acted as interpreters and wrote up the village records in Bengali, locally known as *dagchittas*.

267. The local establishment consisted of 3 Sub-Deputy Collectors, 3 Sub-Deputy Collectors' clerks, 2 district surveyors, 4 *tahsil mohurrirs*, 1 supervisor *kanungo*, 93 *mandals*, and 29 candidates, making a total of 135 local men. *Mandals*, during the whole period of their employment on the survey, received the salaries of their permanent appointment, which ranged from R6 to R10 per mensem, and in addition, they were remunerated for their survey work at rates which averaged about R1-8 per 100 acres of approved work. Candidates, not being Government servants, were paid at double the rates allowed to *mandals*. The average areas completed by each of the different classes of agencies were as follows:—

	acres.
By Hindustani *amins*	3,150
„ Bengali „	2,385
„ *mandals* (old)	1,708
„ *mandals* (new)	1,144
„ candidates	1,268

* Lieutenant-Colonel Sandeman thus reports on Mr. Freeman: "He is thoroughly trustworthy and devoted to his work." The Settlement officer, whilst thanking him for the assistance he has rendered and the energy, care, and attention he has displayed, writes, "your experience of Revenue and Settlement work has been very valuable throughout."

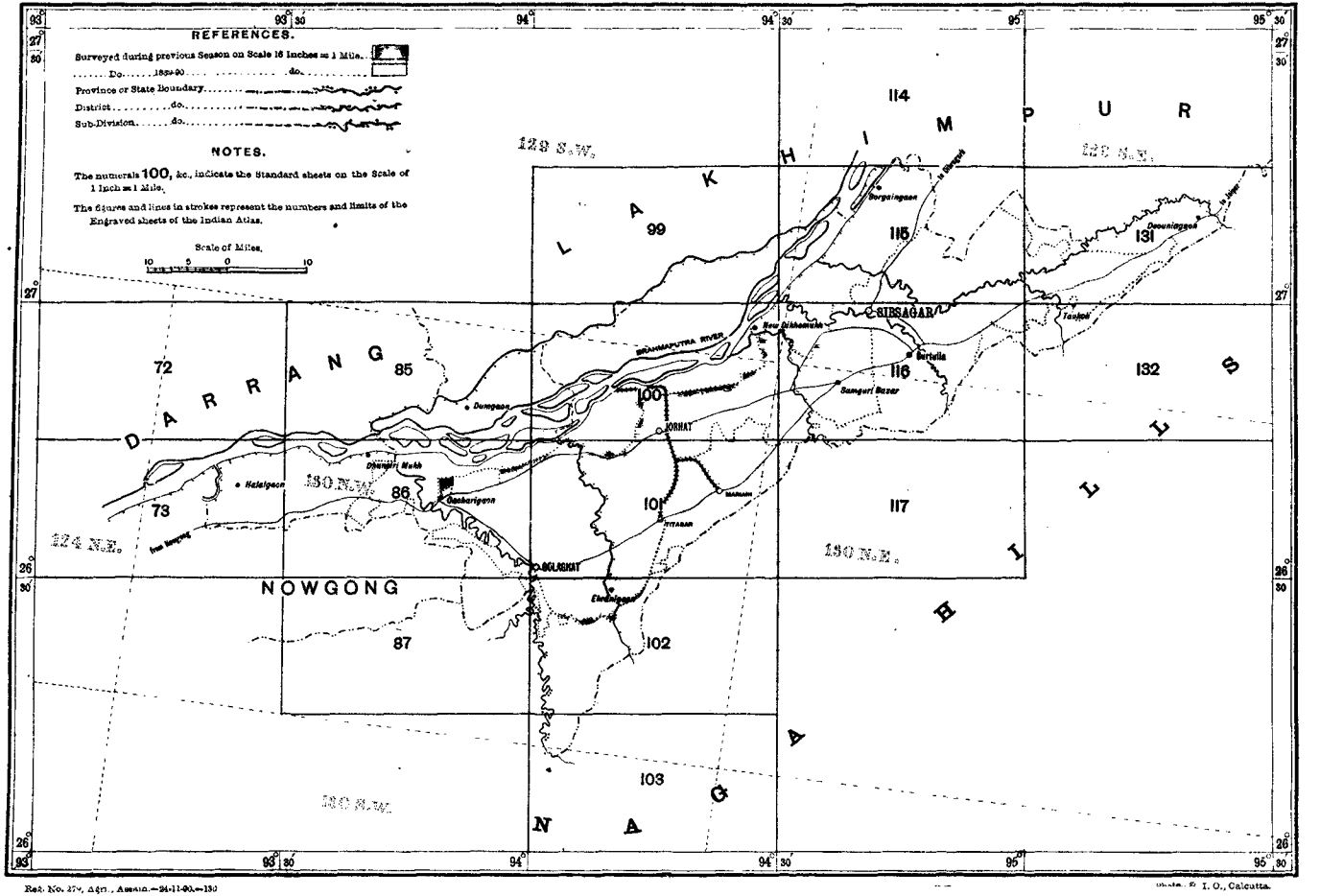
Of Mr. A. W. Smart he reports that he is a most zealous and competent surveyor, and has maintained his reputation during the past season; and of Mr. N. Bedford that he has ably assisted Mr. Freeman and is gaining experience.

The following members of the Native establishment are also mentioned as having worked well:—Puran Chund, Badri Pershad, Nidha Lal, Golam Gaus Khan, Joala Pershad, Hari Singh and Fazaldad.

ASSAM SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT SIBSAGAR.

No. 6 PARTY.



Reg. No. 279, Agri., Assam.—24-11-90.—130

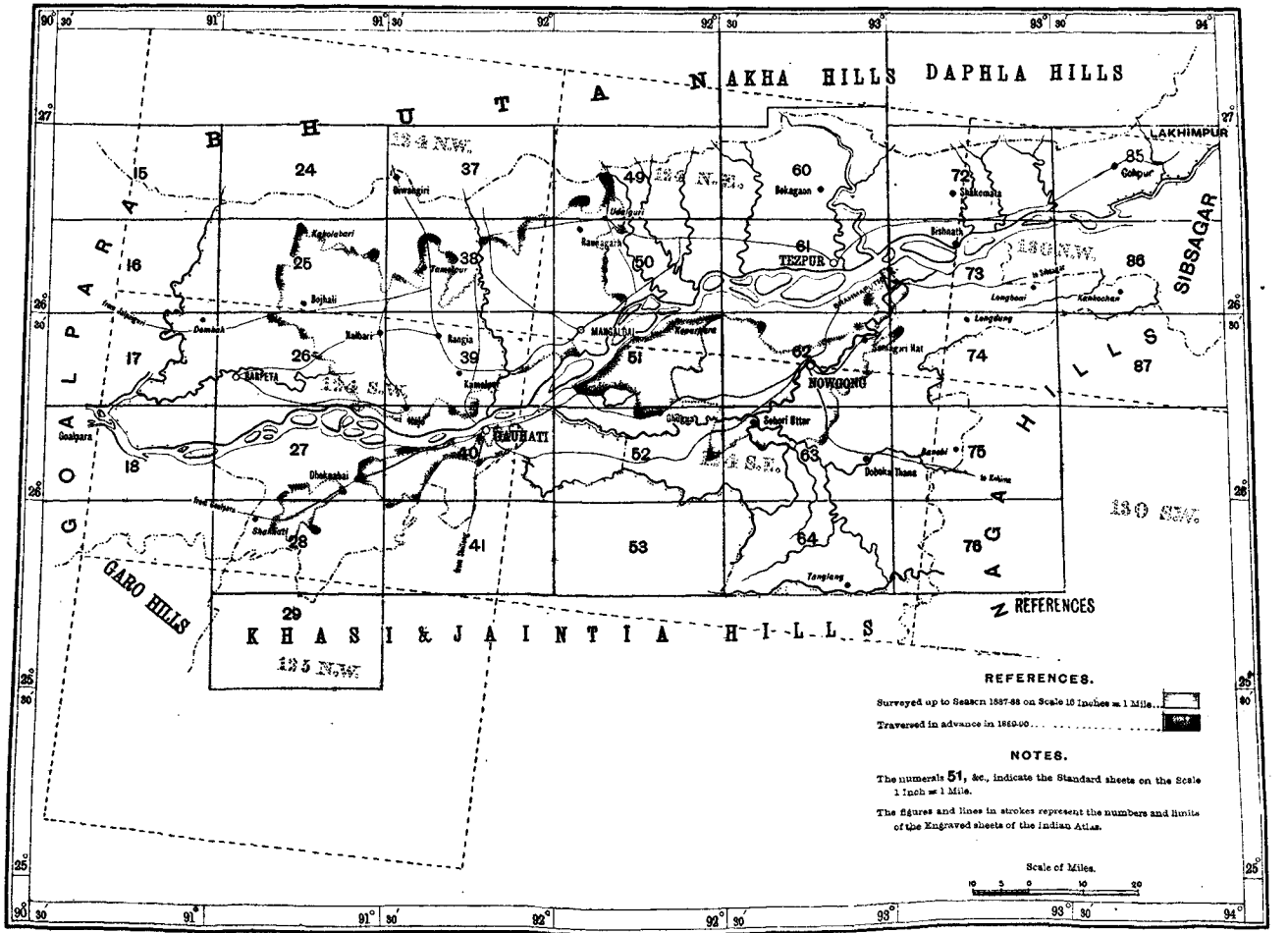
Reg. No. 279, S. I. D.—31-12-90.—550.

Photo. S. I. O., Calcutta.

ASSAM SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTS. KAMRUP, DARRANG, & NOWGONG.

No. 6 PARTY.



Reg. No. 267, Agri., Assam.—24-11-90.—150.
Reg. No. 227, S. I. D.—5-12-91.—550.
Photo., S. I. O., Calcutta.

The largest area surveyed during the season by a *mandal* was 1,991 and by a candidate 2,116 acres.

268. The out-turn of the season is given in the following statement:—

District.	Cadastral Survey.			Traverse Survey.		
	Number of villages.	Number of fields.	Area in square miles.	Number of *mauzas*.	Number of villages.	Area in square miles.
Sibsagar . .	599	146,007	713·49	18	345	432·30
Nowgong . .	...	...	...	4	192	143·50
TOTALS .	599	146,007	713·49	22	537	575·80

The area surveyed cadastrally contains the following tea and other estates:—

Class of Estate.	Number.	Area in acres.	Area in square miles.
Lakhiraj (rent-free)	17	7,871	12·29
Nisf-khiraj (half-rent) . . .	116	726	1·13
Tea estates.			
Fee-simple grants	96	84,581	132·16
Lease rule „	87	31,593	49·36
Gardens (*potta*)	18	64,91	10·14
TOTALS .	334	1,31,252	205·08

269. The detail survey has been tested by 1,468·42 linear miles of check lines. These measurements averaged 2·06 linear miles of cadastral survey. The recorded (*khasra*) entries of 35,029 fields, or about 24 per cent. of the total number surveyed, were examined in the field by European surveyors and inspectors. The entries in the *khasra*, or village records were also checked by Sub-Deputy Collectors and *munsarims* of the Settlement Department who were associated with the survey staff for the purpose. The various tests applied show the work of both the local and imported men to be of very good quality. The traverse survey has been checked by observations for azimuth taken at 43 stations and by connections with 3 stations of the Great Trigonometrical Survey.

270. The cadastral work completed during 1888-89 in district Sibsagar was revised on the basis of objections raised by the *rayats* on the distribution of *jamabandi* slips by the Settlement Department. Fourteen revision squads, each consisting of a survey *amin* and a settlement *munsarim*, were engaged in the work from the 1st November 1889 till about the 15th March 1890. The number of objections enquired into was unusually large, but the percentage of cases to the number of holdings was somewhat smaller than during the previous year.

271. Village tri-junctions have been permanently marked by stone prisms 3 feet long with 1 foot sides. Intermediate traverse stations along boundaries, and all sub-traverse stations, have been marked by mounds of earth 6 feet in diameter and 3 feet high: the other stations have been marked by branches of the *semal* tree being planted at a uniform distance of 5 feet to the magnetic north of all of them. The demarcation of the *lakhiraj* and *nisf-khiraj* estates and grants comprised in the area surveyed during 1887-88 in district Nowgong was effected during the year by a sub-surveyor. The demarcation of the Sibsagar estates and grants will be undertaken during next cold weather.

272. The season's out-turn has been mapped on 979 sheets on the scale of 16 inches to the mile. The Settlement officer has been supplied with tracings

on vellum cloth of all the cadastral sheets and with the original *khasras* and *dagchittas* having the areas of fields entered in English and in local measure. He has also been provided with separate maps of all *lakhiraj* and *nisf-khiraj* estates. Instructions were issued by the local Government in 1889 that the maps of villages, the lands of which were either all covered with jungle or were entirely under cultivation, were not to be printed, single copies only being supplied to the Settlement officer. Experience has, however, already shown that single copies will not answer for maps of villages entirely under cultivation, and the question was again brought before the Chief Commissioner in June last, when it was decided that all maps, excepting those that contained no cultivation whatever, were to be printed.

273. In accordance with the requisition of the Chief Commissioner regarding the adjustment and survey of the disputed portions of the boundary between the states of Khairim and British Jaintia, Mr. Wilson, Assistant Surveyor, was on the 26th May 1890 deputed to accompany the Deputy Commissioner of the Khasi and Jaintia hills to the disputed localities to map the boundary that might be determined on by that officer. The work of demarcation and survey was brought to a close on the 23rd June, having occupied nearly a month. The long-standing disputes between Khairim and Jaintia have thus been finally settled.

274. The attitude of the people towards the survey was satisfactory on the whole. A prosecution of some *rayats* of the *chettia* caste was instituted by the Deputy Commissioner of Sibsagar at the instance of the Settlement officer, but no prosecution was undertaken directly by the Survey Department.

275. The health of the party was not as good as in the previous year owing to the work having extended to the densely wooded tracts bordering on the Naga hills. Mr. Smith had a bad attack of malarial fever which necessitated his going on three months' leave early in the field season, and most of the traverse sub-surveyors suffered from fever for varying periods during November, December and January.

276. The Chief Commissioner of Assam, the Honourable J. W. Quinton, C.S.I., inspected the field office of the party at Jorhat on the 22nd February 1890.

277. The Deputy Commissioners of Nowgong and Sibsagar and the Sub-Divisional Officers of Golaghat and Jorhat afforded the survey every necessary assistance. The Settlement officer, Rai Sarat Chandra Banerjea Bahadur, co-operated most heartily with the survey throughout the year.*

THONGWA DISTRICT, LOWER BURMA.

No. 7 PARTY.

278. This party has this year been employed chiefly in the Thongwa district. The traverse section left recess quarters at Rangoon for the field on the 2nd November 1889, and continued work till the 14th May 1890. The two cadastral sections left Rangoon on the 30th November 1889, and continued field work till the 10th May. A detachment from the traverse section, composed of one assistant surveyor and five sub-surveyors with their squads of measurers, was despatched to the Amherst district on 29th January 1890 to commence the preliminary operations for the cadastral survey in the following year, and completed the traverse survey of 165 square miles in the Zaya and Bilugyun townships.

Personnel.

Mr. F. W. Kelly, Officiating Deputy Superintendent, 3rd grade, in charge up to 26th August 1890.
Mr. H. R. Littlewood, Surveyor, 1st grade, in charge from 27th August 1890.
Mr. G. W. Jarbo, Surveyor, 4th grade.
„ J. S. Swiney, Assistant Surveyor, 1st grade.
Mr. F. B. Powell, Assistant Surveyor, 2nd grade.
Mr. J. A. T. Haddock, Assistant Surveyor, 3rd grade.
21 sub-surveyors and others.

Temporary Establishment.

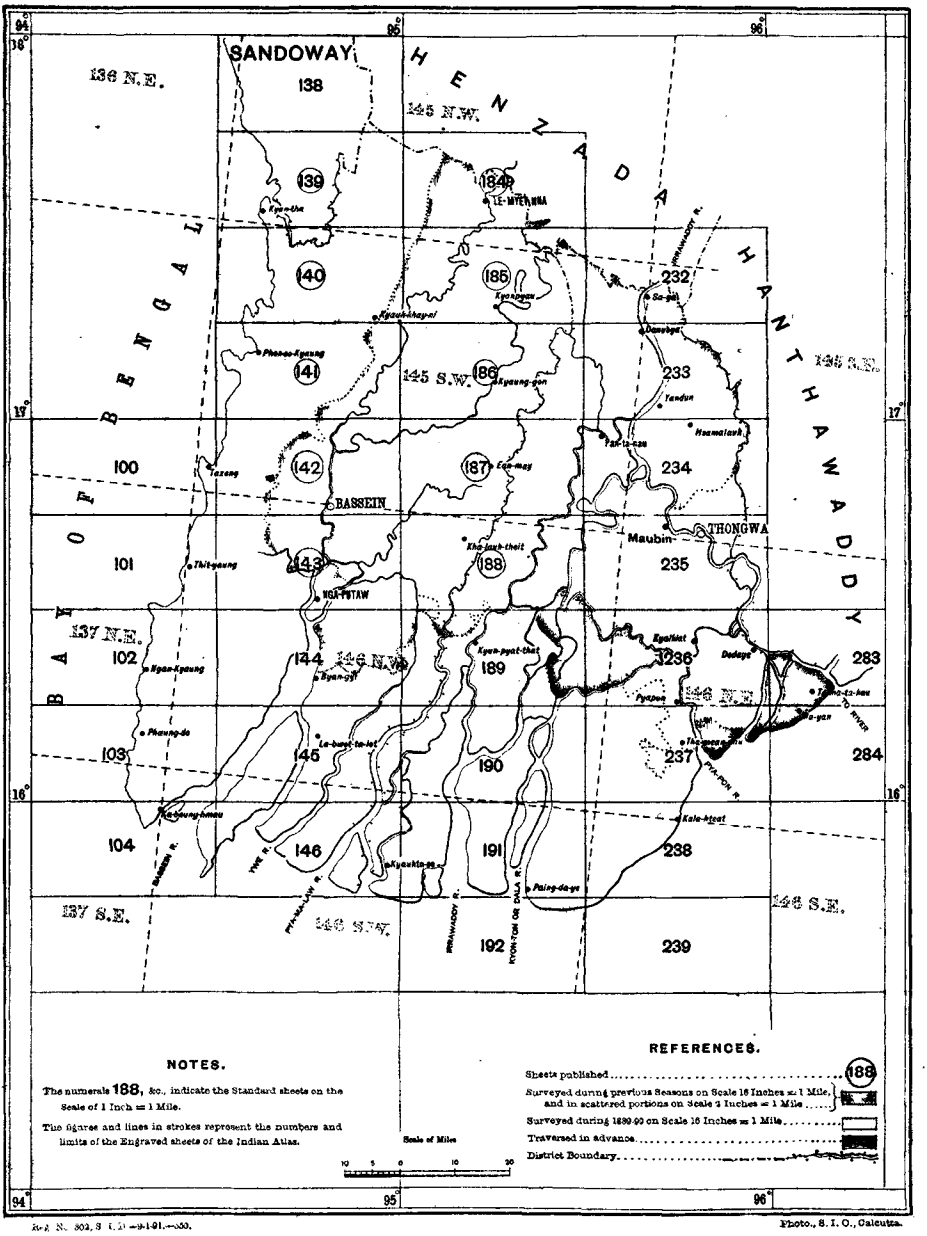
177 field surveyors and others.

* Mr. Barrett reports very highly of the assistance he received from Mr. J. H. O'Donel, the officer in charge of the cadastral section. He also commends Mr. Wilson, who held charge of the traverse section. The following members of the native establishment are likewise brought to favourable notice:—Sakhawat Hossein, Khurshed Hossein, Janardhan Rao, Mohan Singh, Dilawar Khan, and Rajab Ally, sub-surveyors; Ganga Ram, computer, and Golam Hyder Khan, draftsman, of the professional establishment, and Jhuni Lal, Haraknarain, and Baboo Sitanath Chuckerbutty, of the cadastral establishment.

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTS. BASSEIN & THONGWA.

No. 7 PARTY.



NOTES.

The numerals 188, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.

The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.

REFERENCES.

Sheets published 188

Surveyed during previous Seasons on Scale 16 Inches = 1 Mile, and in scattered portions on Scale 2 Inches = 1 Mile .....

Surveyed during 1889-90 on Scale 16 Inches = 1 Mile .....

Traversed in advance .....

District Boundary .....

Reg. No. 302, S. I. D.—9-1-91.—550.

Photo., S. I. O., Calcutta.

279. The traverse survey in the Thongwa district was extended over the complete circles of Tawhla and Tomayan of the Dedayé township, such portions as had been assigned for survey in the circles of Pyindayé, Thazi and Pyapôn, and over a portion of the Kyôntôn circle of the Pyapôn township; the out-turn comprised an area of 736 square miles. Of this area, 361 square miles have been surveyed in detail, leaving an area of 375 square miles in Thongwa district traversed in advance for cadastral survey in 1890-91. Of this latter area, 316 square miles are to be surveyed in detail on the 16-inch and 59 square miles on the 4-inch scale. A portion of the Kyôntôn circle to the west, containing an area of 95 square miles, has been enclosed by a main circuit, and contains 38 *kwins* that remain for traverse as well as detail survey on the 4-inch scale.

280. The cadastral area completed comprises a portion of the Seiktha circle (now complete) and the four remaining circles of the Thongwa township; three complete circles and part of the Tawhla circle in the Dédayé township, and those portions assigned for survey in the three circles of the Pyapôn township.

281. The areas traversed and cadastrally surveyed during the season are shown in the following statement:—

Districts.	Traverse Survey.		Cadastral Survey, 16" = 1 mile.		
	No. of villages.	Area in square miles.	No. of villages.	No. of fields.	Area in square miles.
Thongwa	391	736·01	453	448,713	1033·26
Amherst	89	164·60	...	...	...
Totals .	480	900·61	453	448,713	1033·26

The out-turn of cadastral survey is 202 square miles in excess of that of the previous year; this increase has been obtained by enlarging the establishment of *amins* without adding to the European supervision, and the cost-rate of the work has been thus reduced from ₹135 to ₹115½ per square mile.

282. Of the area surveyed in detail, 550 square miles are under cultivation and 484 square miles consist of jungle and waste including water. The average size of the field is 0·78 acre, as compared with 0·37 acre last season.

283. The same procedure was adopted as during the past seasons, for the marking of the traverse stations, *viz.*, by sinking pottery cylinders nearly flush with the ground and covering them over with mounds of earth; 12,919 stations were so marked during the season and they were made over to the custody of the village *Kyedangyis* (headmen), receipts on printed forms in the Burmese being obtained for them. This procedure was adopted for the permanent marks of the advance traverse survey. For the marks that had been utilized by the cadastral section, 2-inch skeleton plans of each *kwin*, showing the stations and lines, were prepared in duplicate on printed forms and signed by the Deputy Commissioner of the district; the village *Kyedangyi* then accompanied the field surveyor, and having had all the stations pointed out to him, signed the forms, retaining one copy; the duplicate was lodged in the Survey office, and forwarded at the close of the season along with the remaining forms of the circle to the Deputy Commissioner, to whom two sets also of skeleton maps of each circle on the scale of 2 inches=1 mile, showing the permanent marks in *kwins*, have been supplied.

284. Observations for azimuth, as a check on the traverse survey, were made at 96 stations. The cadastral survey was tested by 2,093 linear miles of check survey, of which 287 miles were measured by Europeans and 1,806 by inspectors.

285. Revision survey in the current season's work was commenced by the Settlement Department on the 15th February and continued to the end of the season. The revisions in seven circles, comprising an area of 513 square miles, were completed and entered on the cadastral sheets. The revisions that were found necessary were almost entirely due to the want, at the time of survey, of

properly defined limits of garden lands. The area remaining for revision by the Settlement Department is 520 square miles contained in six circles, two of which, Maletto and Thongwa, comprising an area of 260 square miles, contain hardly any cultivation.

286. The season's cadastral area is mapped on 1,326 sheets. Of the sheets of the past season, 780 have been sent to Calcutta to be printed; the remainder will be despatched before the close of the recess season, with the exception of two *kwins* of Inzaya and Kattiya circles containing 81 sheets and comprising an area of 72 square miles, which, owing to their inconveniently large size, are required to be sub-divided into smaller *kwins*. In the current season's work a sub-division into smaller *kwins* of five *kwins* of the Maletto and Thongwa circles, comprising an area of 200 square miles and contained in 163 sheets, is also required. Intimation of these changes was received from the Settlement officer after the completion of the survey and mapping. The subject has been referred to the Director of Land Records and, as requested by him, an estimate has been submitted for an additional grant from provincial funds to enable this work to be completed.

287. The 2-inch maps of Bassein district, contained in eight quarter sheets, two of which contain a portion of Thongwa district, have been completed and await final examination prior to being sent to Calcutta. Of the Thongwa district, 14 quarter sheets out of a total of 36 have been completed and 6 are well advanced.

288. The scheme for the employment of Burmans and Karens has progressed. During the season 69 have been employed, against 67 in the previous season. In addition to the Burmans employed, 28 pupils were taught surveying. The area surveyed by Burmans and Karens is 419 square miles contained in 252 *kwins*. Revisions in the season's work in 127 *kwins* were completed by 1 Burman inspector and 3 Burman field surveyors. Of 67 Burman field surveyors who were on the rolls in 1888-89, 59 rejoined for work during the season; of 52 men who had earned deferred pay in 1888-89, 46 rejoined. Out of 69 Burmans, 64 have earned rewards this season amounting to R1,227-10-4; the average earnings per man for the season being R168-2-5, as compared with R114-7-1 last season. In office, 51 Burmans and Karens were employed as compared with 42 during last year. The number of local men on the rolls and their length of service is shown in the following statement:—

Period of service.	Number of men.
1st year of service	13
2nd " "	22
3rd " "	30
4th " "	4

Of the total out-turn for 1889-90, *viz.*, 1,033 square miles, 419 were surveyed by 69 Burmans and 614 by 44 Hindustanis, the daily rate per man being respectively 32 and 52 acres, and the average size of the fields 0·85 and 0·72 acre. From these figures it is evident that the employment of Burmans, although desirable for many reasons, has not yet proved to be an economical measure.

289. The Thongwa-Bassein boundary between Kyôn-Kazin circle of Bassein, and Hnègyo and Kyôntôn circles of Thongwa, referred to in paragraph 238 of last year's General Report, has been adjusted; the demarcation and survey were completed this season and a trace on the 16-inch scale with details up to the limit of Thongwa district was supplied to the Settlement officer.

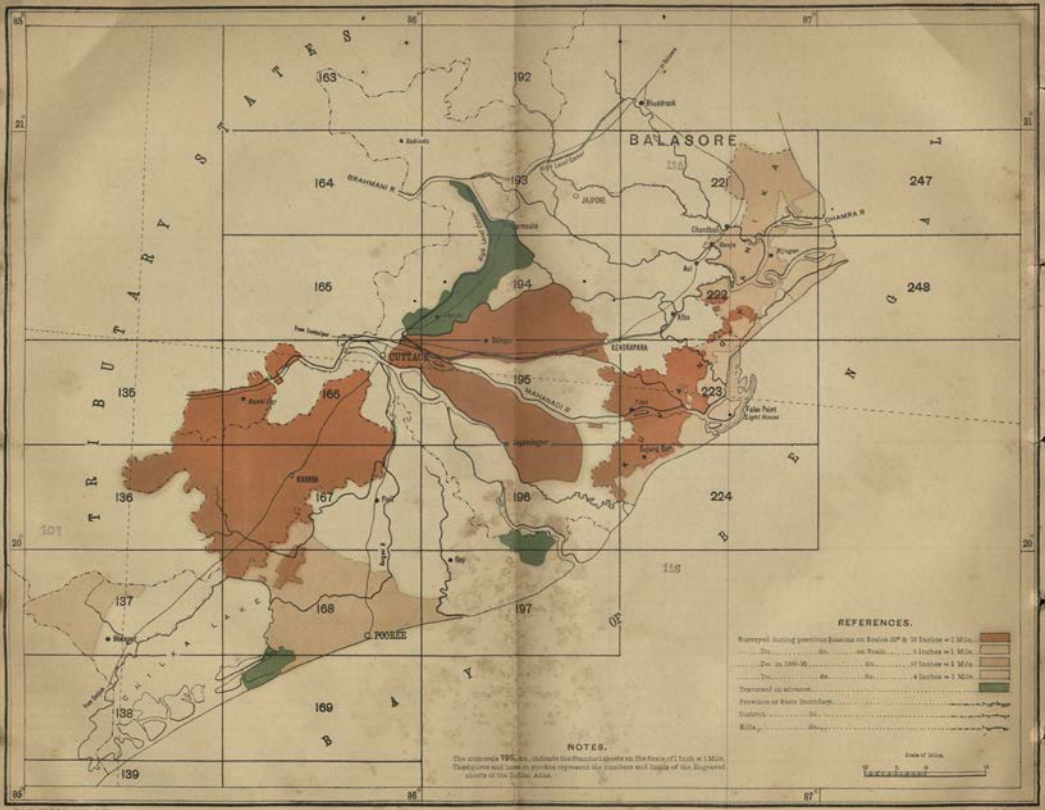
290. The health of the party was not good. There was no epidemic disease, but during the month of November diarrhœa and dysentery prevailed among the men of the boundary camp in the Thongwa district, and towards the close of the season a number of men suffered from fever in the Amherst district. Fifteen deaths occurred during the season and fourteen men were invalided and sent back to their homes in India.

291. During the ensuing season, the traverse section of the survey will continue work in the Amherst district, in the Bilugyun, Gyaing-Ataran and Salween townships, in which it is expected that 630 square miles of country will

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY OF ORISSA, DISTRICTS CUTTACK & POOREE.

No. 8 PART.



be traversed, in addition to the 165 square miles done during the previous season. The cadastral section will complete the area remaining in the Thongwa district, *viz.*, 375 square miles, and will commence the cadastral survey in Amherst where an out-turn of 225 square miles is expected.

292. On the 28th August, Mr. Kelly retired from the service and the charge of the party devolved temporarily on the senior assistant, Mr. H. R. Littlewood. Mr. Kelly commenced his career in the Junior Division, in which he served for 28 years when he was promoted to the Senior Division. He now retires after an honourable career of nearly 36 years in the Revenue Branch; he has, however, obtained the appointment of Superintendent of Survey under the Government of the Straits Settlements, for which it is believed he is in every way well fitted.*

ORISSA.

No. 8 Party.

293. This party, as in previous seasons, was employed in detached sections, each section being under the immediate supervision of a surveyor or assistant surveyor whilst the whole was under the superintendence of a Deputy Superintendent. In the previous year he had in addition the superintendence of the Calcutta Survey and of a detachment surveying the Burdwan Raj Khas Mehals; his head-quarters were then fixed in Calcutta, but as it was found impossible for him to exercise sufficient control over the work in Orissa, a change was made; the Calcutta City survey, the out-door work of which was mostly finished, was placed under the Assistant Surveyor-General in charge of the Drawing office, and the control of the Burdwan detachment was also removed, whilst the head-quarters of the Deputy Superintendent in charge of the Orissa party were transferred to Cuttack.

Personnel.

Colonel S. H. Cowan, S. C., Officiating. Deputy Superintendent, 3rd grade, in charge up to 28th October 1889.
Mr. W. H. Patterson, Officiating Deputy Superintendent, 3rd grade, in charge from 29th October 1889.

Kujang and Kanika Section.

Mr. R. B. Smart, Surveyor, 3rd grade.
„ J. P. Barker, Assistant Surveyor, 2nd grade, from 1st December 1889.
6 sub-surveyors and others.

Temporary Establishment.

Mr. A. H. Pyster, Supervisor.
69 inspectors, computers and others.
209 *mustajirs, jimbadars,* and others.

Pooree Section.

Mr. R. C. Ewing, Surveyor, 4th grade.
„ C. S. Gasper, Assistant Surveyor, 3rd grade.

Temporary Establishment.

Mr. B. Hickie, Supervisor.
65 inspectors, computers and others.
286 *patwáris, sarbarakars, tonkidars* and others.

Cuttack and Pooree Traverse Section.

Mr. C. S. Kraal, Assistant Surveyor, 1st grade.
„ J. A. Higgs, Assistant Surveyor, 2nd grade, to 7th March 1890, detached on special survey of Keonjhar boundary from 8th March to 11th June 1890.
11 sub-surveyors and others.

Temporary Establishment.

11 sub-surveyors, computers and others.

294. Colonel S. H. Cowan who was in charge last year, continued in charge of the party till the 28th October 1889, when he proceeded on furlough, and was relieved by Mr. W. H. Patterson, who superintended the field and recess operations practically throughout the year.

295. Mr. Patterson, with the head-quarters office, arrived at Cuttack on the 4th November 1889, and during that month the establishment took the field in three detachments; the first under Mr. R. B. Smart was engaged on cadastral work in Killa Kujang and in Killa Kanika, besides the survey of some jungle tracts on the 4-inch scale; the second under Mr. R. C. Ewing was employed on

* Mr. Kelly speaks in high terms of his assistants and thanks them for their services, stating,—"My charge which commenced on 6th September 1887 is now given up on my retirement from the Survey of India. I have to thank those with whom I have worked with such pleasure, and may, I think, safely venture to say that there is not a more efficient body of assistants in any party of the Survey of India. We have co-operated with perfect harmony and good-will, with a single eye to the interests of Government and the credit of the Department with which I have been connected for 35 years." He also specially refers to Mr. Littlewood as a capable, energetic and all round good officer, and recommends him for promotion to the Senior Division. He also selects the following members of the Native Establishment as being worthy of special mention, *viz.*, Nand Lall Chatterjee, Shosi Bhusan Ghosal, Preo Nath Banerjee, Dindyal, Mahomed Umar, Wahid Ali, Mahbub Ali, Abrew, Maung Hpo, Kali and Issan Chandra Ghosal.

the traverse and cadastral survey of Pooree; and the third under Mr. C. S. Kraal was employed on traverse work in both Pooree and Cuttack. The total area surveyed during the season was as follows:—

Nature of Work.	Area completed in square miles.
Traverse survey	532
Cadastral „ 16-inch scale	644
Topographical survey of jungle tracts, 4-inch scale	113

Besides the above three detachments, Mr. J. A. Higgs, Assistant Surveyor, was deputed on special work to relay the disputed boundary between district Singhbhoom and Keonjhar (a tributary *mehal* in Orissa).

296. The Deputy Superintendent during the field season periodically visited the offices of the three sections in Kanika, Pooree and Cuttack, and inspected the field work; he also visited the training classes in districts Cuttack and Pooree, established to instruct the local agents in field-surveying and record-writing. Field work was closed in the early part of June 1890, when the several sections returned to recess quarters at Cuttack, where all the offices which had heretofore been in different houses were located in one building for the more effective supervision of the work.

Survey of the Ward's estate of Killa Kujang, district Cuttack.

297. On taking the field in November 1889, to complete the small area remaining for survey in this estate, some delay was experienced before the men who had been trained the season before and nominated by the Sub-manager for the completion of this work, were forthcoming. Some of the men nominated did not attend at all, and it was found necessary to employ trained men of Orissa who had worked as *amins* in previous years to take the place of the absentees. Coolie labour was with difficulty obtained, and the work therefore was completed under adverse circumstances. The out-turn of work was as follows:—

Number of villages.	Number of fields.	Number of *kittas* (sub-divisions of fields).	Area in square miles.
42	5,106	7,106	22

The average area of the field is 2·76 acres.

298. The *khasra* writing of these 42 villages was also completed. Twenty-four linear miles of check survey was run by Europeans, who also tested the entries of 3,060 fields; and native inspectors ran test surveys over 26 miles and checked the entries of 1,113 fields, giving an average of 2·27 linear miles of check work per square mile of survey, and a percentage of 81·7 of the *khasra* entries. Field work was not completed till the 20th of January 1890, the delay being due to the non-attendance of men nominated for survey, and the difficulty in obtaining coolies.

299. After the completion of the survey, a sub-surveyor and a few *amins* were sent to define on the village sheets of the present and previous seasons' survey, the limits of lands acquired by Government along the Kendrapara extension and Taldanda canals, and along the Ramchandi Nadi; and also to mark off the limits of the several locations at Jambu, False Point, Dodswell Island and Plowden Island. Some portions of the acquired lands were permanently demarcated by the Public Works Department, and these marks were mapped on the sheets. Where permanent marks did not exist, an overseer was deputed to accompany the sub-surveyor, and put up temporary marks to indicate the limits; these have also been shown on the sheets. In only one village is there some acquired land still not defined. The Executive Engineer reported that this would be demarcated in November 1890; when intimation is received of this being ready, the boundaries will be surveyed and inserted on the sheet.

300. The records of 118 villages were made over to the Settlement officer during the recess months. In all, the records and tracings of 447 villages

were furnished by the end of September 1890. The records remaining in the Survey office are those of some 15 villages which are pending the settlement of boundary disputes. These boundaries are in course of settlement, and when decided the records will be completed and made over to the Settlement Department.

The standard sheets of Sections 195 N. E., 195 S. E., 196 N. E., 223 N. W., 223 S. W., 223 N. E., 223 S. E., and 224 N. W., on the 2-inch scale, containing the Kujang estate, were completed during the recess months. The final examination only remains, and when this is done the sheets will be ready for despatch to the head-quarters office, Calcutta.

301. The other records of this estate will also be submitted at the same time. The village sheets are kept back for the insertion of the corrections which are being periodically received from the Settlement officer after he has attested the village records. It may be here mentioned that the corrections hitherto received have not been more than might be expected from slight changes in the boundaries of fields, and extension of cultivation made subsequent to survey. The *khasra* entries recorded in the field by the *amins* under the Survey Department have been found by the Settlement officer to be satisfactory at the time of attestation.

302. The survey of the estate was commenced in season 1887-88, and completed in 1889-90. The statement at page 84 gives the cost rate of the survey of the whole estate.

The area of the estate noted as 369·5 square miles is not final, and the correct area will not be known until the boundaries of 15 villages noted above have been settled.

303. As mentioned in paragraph 259 of last year's General Report, 117 *jimbadars* had been trained for the work of survey, but as this number was found to be quite insufficient, 120 other local men were also trained, making a total of 237 local men, who aided in the 16-inch detail survey and in the preparation of the *khasras*. The survey of Kujang has been completed entirely by local agency, supervised mostly by inspectors from Upper India. A few Uriyas have also been employed on supervision work; these men have done well, and encouragement has been given to promote intelligent and deserving Uriyas to the post of inspectors.

The total number of stones embedded to mark the tri-junction points of village boundaries and theodolite stations of traverse survey in the entire estate was 4,068, giving an average of 11 stones per square mile.

Survey of the Ward's estate of Kanika, Orissa.

304. This estate is divided into four divisions, *viz.*, Kaldip, Kerara, Chamuka, and Panchmuka: all are contiguous; the first three are situated in the Cuttack district, and the fourth in the Balasore district. The Baitarani and Dhamra rivers form the boundary between the two districts. The area of the estate in district Cuttack is 282 square miles, and that portion of it in district Balasore is 159 square miles, making the total area 441 square miles. The work completed during the previous year consisted of the traversing of the entire estate, the cadastral survey of 16 square miles and the topographical survey on the 4-inch scale of 50 square miles of jungle tracts along the coast. The area surveyed this season was as follows:—

Districts.	Number of villages.	Number of holdings or fields.	Number of *kittas* or sub-divisions of fields.	Area in square miles.		Total square miles.
				16-inch scale.	4-inch scale.	
Cuttack	341	105,080	167,120	136	...	216
	10	...	...	...	5	
	Jungle blocks	...	...	...	75	
Balasore	224	87,089	136,909	126	...	159
	10	...	...	...	13	
	Jungle blocks	...	...	...	20	
Totals	585	192,169	304,029	262	113	375

305. This completes the survey of the estate. The detail-survey was commenced in all four divisions simultaneously, because the local men who had been trained for survey objected to work in the adjoining divisions, on the plea that they would be far away from their homes. There was some delay in getting together the men who had been taught during the previous season; most of them came reluctantly, the Manager having to send peons to bring them, and when they did come they made various excuses to get away. Several had forgotten what they had learnt and had to be instructed again before they could be usefully employed. The Manager had named 148 *mustajirs* for instruction; of this number 120 did work, and 28 for various reasons failed either to appear, or after instruction refused to work or left the estate. In addition to these 120, about 180 other men from Orissa, who had in previous years assisted in the survey of Khurda, Angul and Kujang, were employed. The attendance of the *rayats* was with difficulty obtained along the eastern parts of the estate, as the ground there is in a great measure cultivated by non-resident *rayats*; this is owing to the prevalence of inundations and the devastating effects of storm-waves to which that coast is so subject. There are no villages between the Matai river and the sea coast, and this increased the difficulty in procuring village aid for survey work. The Manager, however, made as good arrangements as were possible for providing the *amins* and surveyors who were working along the coast with coolie labour, but a certain amount of delay and expense could not be avoided in sending men from distant places. In other parts of the estate the attendance of the villagers was good.

306. The field work was closely tested by the assistants and inspectors; 288 linear miles of check survey by the former, and 869 linear miles by the latter, were run over the 262 square miles of detail survey on the 16-inch scale, giving an average of 4·4 linear miles of check to each square mile of survey. For the jungle tracts on 4-inch survey, test lines of 5 linear miles in length were run, besides the traverse lines of polygons which checked themselves. Of *khasra* entries, 16,051 fields were tested by assistants, and 67,884 fields by native inspectors, giving an average of 43·7 per cent. on the whole. The average size of the field is 1·15 acres. The *mustajirs* were paid at a contract rate of ₹2-8 per 100 acres or ₹16 per square mile for field survey; coolie labour, which was separately paid for, cost on an average from ₹30 to ₹40 per square mile, the rates depending on the amount of work each *mustajir* was able to accomplish in the day, as the same number of coolies had to be provided for a slow as for a fast worker. The payment of coolie hire alone has increased the cost per square mile of field survey from about ₹26, the cost rate in Banki, to ₹46 and ₹56 per square mile in Kanika.

The *khasra* entries and preparation of the records were found by the Settlement officer and Manager to be on the whole satisfactory, considering the agency that was employed, but these results were only obtained after much labour was bestowed in closely watching the preparation of the records according to certain rules drawn up by the Manager and approved of by the Collector of Cuttack. These rules were printed, and were circulated with other instructions to each *mustajir* and inspector.

307. During the season, the tracings and records of 440 out of the total number of 632 villages, were supplied to the Settlement officer. The boundaries of 55 villages along the exterior limits of the estate are in dispute, and will not be settled until the ensuing season. The records of the other 137 remaining villages will be supplied to the Settlement officer by the end of next November.

The number of villages, with area of the complete estate, is as follows:—

Districts.	Number of villages.	Number of holdings or fields.	Number of *kittas* or sub-divisions of fields.	Area in square miles.		Total square miles.
				16-inch scale.	4-inch scale.	
Cuttack . . {	388	115,341	184,674	152	...	282
	10	...	...	...	5	
	Jungle blocks	...	...	...	125	
Balasore . . {	224	87,089	136,909	126	...	159
	10	...	...	...	13	
	Jungle blocks	...	...	...	20	
Totals .	632	202,430	321,583	278	163	441

The average area of the field is 1·39 acres.

308. The field work, *i. e.*, the cadastral survey and the *khasra* writing, was entirely done by local agency. A few inspectors from Upper India, aided by a fair proportion of Uriya inspectors, supervised the work under the general control of European assistants. Every encouragement has been given to employ local agency in responsible posts. The 4-inch survey of the jungle tracts was done by sub-surveyors and shows all the main streams which constitute the only topographical features to be met with. There are 20 villages, or rather blocks, falling within the jungle area which have been separately demarcated and mapped on the 4-inch scale; this scale was adopted as there were no details of cultivation to survey, the villages being uninhabited. With the traverse data these villages can be plotted and mapped on the 16-inch scale whenever required.

309. In this estate 2,627 stones have been embedded to mark the tri-junction points of village boundaries and theodolite stations falling in or near the boundaries common to two villages, giving an average of 6 permanent marks to each square mile; this does not include the number of tri-junction stones erected by the Manager. Towards the north-east corner of the estate there are some uninhabited villages, where a few stones still remain to be embedded. Temporary marks were placed at the time of traverse survey, but these will be supplemented by permanent marks during next field season.

310. During the season under report, it was not settled whether Shortt's Island belonged to the Kanika estate or to Government, and the survey of the island was therefore held in abeyance, pending a reference to the Board of Revenue by the local authorities. By letter No. 44 T. M., dated 31st May 1889, from the Government of Bengal to the Board of Revenue, it was decided that Shortt's Island belonged to Government and that a survey was to be made of it; this will be done during the ensuing season, as the orders of the Bengal Government reached the Deputy Superintendent of Survey after the field parties had been withdrawn to recess quarters last June.

311. The original village sheets on the 16-inch scale are in an advanced state of completion, and a beginning has been made with the compilation of the standard sheets on the 2-inch scale. All the sheets have been projected and the reduction by pentagraph of the village boundaries and details has been commenced on 3 sheets. The records of computations are also well advanced, but none of the records will be completed till next recess season.

Survey of district Pooree.

312. According to the arrangement made last year, the detachment which had been surveying in Angul, having completed that estate, was employed on the cadastral survey of the Government estates in Pooree. The Collector of the district commenced the demarcation of the village boundaries prior to the field parties commencing work, erecting temporary marks, except at the tri-junctions of villages and at certain other selected intermediate places where permanent marks were to be placed; the latter were to be provided by the Survey Department. In December this work was handed over to the Settlement officer who was then appointed.

313. As there was no traverse work in advance on which to commence the field survey, every man who could traverse was put on to that work at first, so as to delay the cadastral section as little as possible. Operations were commenced in the Government estates of Rahang, Krishnagar, Krishnachandra and Kodhar: intermixed with the Government lands were some others belonging to zemindars, which were surveyed at the same time to avoid having to return to that part of the district, as it was understood that eventually the whole would be surveyed. Pargana Oldhar was also included with a detached portion of Pargana Rahang. The following statement gives the out-turn of traverse survey:—

Number of villages.	Number of sub-traverses.	Number of traverse stations.	Number of permanent marks.	Area in square miles.
617	340	9,310	8,835	413

The traverse stations of the Khurda survey of 1875—80 were identified and incorporated with the season's work. Although the demarcation was proceeded with as quickly as possible, the traverse surveyors overtook the demarcation officials, and the professional work was occasionally interrupted. To assist in the demarcation, a few of the survey *amins* who had had some previous training in this work were temporarily transferred. In November heavy rain fell which flooded the country, and not only delayed all survey operations for about a fortnight, but washed away several of the temporary marks, thus causing uncertainty in the lines of boundary, whereby the traverse surveyors were apt to be misled by the villagers who pointed out boundaries which afterwards proved to be erroneous. The area traversed is not as much as was anticipated, but there is always a certain amount of time lost in the first season in a new district, and the curtailment of the field season, owing to the heavy rain which fell in November and the early setting in of the south-west monsoon in June and the non-attendance of many of the responsible villagers, aided in reducing the out-turn. All the tri-junctions of villages and theodolite stations falling on intermediate bends were marked with stones which were supplied by a local contractor, and they cost, including transport from Khurda, ₹56-4 per hundred for the rectangular tri-junction stones, and ₹37-8 per hundred for the stone prisms for intermediate stations.

314. In January, skeleton plots were available for distribution to the field surveyors. Training schools had been established at a few centres during October for the instruction of *patwáris*, *sarbarakars* and others in surveying and plotting. Out of the 463 pupils who attended, 86 failed to learn, but the other 377 all did work more or less well. The cadastral work was nominally commenced in the first week of January, but it was not until March that much progress was really made; in January the total out-turn was only 8 square miles, whilst in February it was 22. It was slow work getting the local men to understand what was required, and they had at first to be closely watched and constantly assisted by the assistant surveyors and inspectors; some of them not finding the work congenial, left on various pretexts.

315. During the month of February, the question was raised of how coolie labour was to be obtained; the Collector did not approve of forced labour, whilst the *sarbarakars* and others were reluctant to supply men. The Collector then decided that payment was to be made at certain daily rates, and on this being made known, the difficulty was partly overcome, but not entirely, as it was found that the villagers would not of their own free will come forward, and there was no authority to enforce their attendance. The Collector rendered all the assistance he could, but it was impossible to prevent delays, and it was not until March, when the Survey Camp officer was vested with powers under Survey Act V of 1875, that the attendance of the villagers was more easily secured. The out-turn of cadastral work is as follows:—

Name of Parganas.	Number of villages.	Number of fields.	Number of *kittas* or sub-divisions of fields.	Area in square miles.
Rahang, Serai, Chaubiskud and part of Oldhar.	554	360,043	1,047,565	360

The average size of the field is 0·64 of an acre. The unit of measurement was a plot of one class of soil in the occupation of one tenant, although it might be sub-divided by one or more ridges into *kittas* for the convenience of agriculture. The assistant surveyors ran 237 linear miles of check survey, whilst the native inspectors ran 614, giving an average of 2·36 linear miles of check per square mile of detail survey.

316. As a rule the *khasras* (record-of-rights) were written by the same men who did the field survey. Some little time was lost at first on account of the uncertainty as to what form should be used, and when the form had been finally approved of, difficulties arose in consequence of the non-attendance of some of those directly concerned, whilst others took upon themselves to mislead the *khasra amins* and get false entries made in the records; in other cases, men nominated by the *sarbarakars* deliberately caused to be recorded the name of

men in whom they were interested in lieu of the real tenants who were too illiterate to note the discrepancy. Whenever these errors were found out at the time of testing the entries they were corrected, but it of course entailed a good deal of extra work on the inspectors. The *khasra* entries were checked in 22,768 cases by Europeans and 45,554 by native inspectors, giving a percentage of 19 on the total.

317. Field work generally closed on the 25th June, but some inspectors were kept out longer with a view to their correcting the *khasra* entries, but the heavy and continuous rain proved to be too much for them. About two-thirds of the cadastral survey was completed by local agency and the remainder by trained *amins* of Orissa; it was necessary to employ the latter, as it was found that 377 *patwáris* would have been unable to finish the 554 villages which had been allotted for the season's out-turn The daily out-turn of work by the local men was small, averaging only about 6 acres; this very materially increases the cost per square mile as the chainmen and coolies are paid daily, and not by contract according to area, as are the *patwáris*.

318. The town and civil station of Pooree was surveyed on the scale of 16 inches to the mile, the very crowded portions only being surveyed on the 32-inch scale; it being almost all *lakhiraj* (rent-free) land, very little was to be gained by adopting a larger scale.

319. The records and tracings of 279 villages have been made over to the Settlement officer, and it is hoped that those of 238 more will be ready in another two months; the records of the remaining 37 villages must be kept back, pending the settlement of boundary disputes.

Traverse Survey of Cuttack.

320. The demarcation of that portion of the district commanded by the High Level Canal was carried on by the Collector, aided by a few *amins* from the Survey Department; these men instructed the *kanungos* and *patwáris* in the work. By April most of the villages were ready and the traverse surveyors from Pooree, after completing what was considered sufficient in that district, were transferred to Cuttack, and worked there without interruption till the 17th June, when the continuous rain drove them in.

The out-turn was as follows:—

Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
405	139	4,493	119

The tri-junctions of most of the villages and the theodolite stations at the intermediate bends of the boundaries were marked by stones similar to those used in Pooree; owing, however, to dilatoriness on the part of the contractor and the early setting in of the rainy season, some of the permanent marks could not be embedded; in these cases baked clay cylinders were used, but stones will be substituted for them next field season. Owing to the small size of the villages there was an average of 37 permanent marks to the square mile.

321. The villagers, unlike Bengalis as a rule, assisted in the survey and in no way obstructed the work. Training schools for the instruction of field surveying and plotting have been established at two centres in anticipation of the cadastral work which will be undertaken during the coming field season. The *zamindars* and others nominated 38 *patwáris* and 95 local men, and these were taught and are now sufficiently advanced to commence field survey.

Survey of Killa Banki, district Cuttack.

322. The field work in this estate had been completed in 1887-88, but there still remained the completion of the 16-inch sheets and the drawing of the 4-inch mapping on 13 sheets. The boundaries of the 5 villages alluded to in last year's report are still in dispute, so both the boundaries as claimed by the

disputants have been shown on the maps; these will be adjusted in the head-quarters office when the disputes have been finally settled. The records have all been lodged in the Surveyor-General's Office.

Survey of Angul, Orissa.

323. The actual survey of this estate was finished last year. During the year the records have been almost entirely completed and will shortly be lodged in the Surveyor-General's Office. As many village tri-junction platforms as were constructed subsequent to survey have been inserted on the 16-inch sheets after verification in the field; there are still some remaining for construction. The exterior boundary of the estate is still undefined, so both the disputed boundaries have been shown on the 16 and 2-inch sheets; these will have to be adjusted hereafter.

Survey and demarcation of disputed boundary between Keonjhar and district Singhbhoom.

324. In accordance with the orders of Government of Bengal as conveyed in their letter No. $\frac{B}{1}$3, dated January 29th, 1889, to the Superintendent of the Tributary Mehals, Orissa, a survey of this dispute which has been in existence since 1855 was undertaken, and in March Mr. Higgs, Assistant Surveyor, with a small detachment was deputed for the purpose.

325. An area of 7 square miles was topographically surveyed on the 16-inch scale, and on to this map the boundary as shown on the 1-inch topographical map of 1859—62 was drawn, it having been decided that the old boundary should be upheld. Mr. Mackenzie was appointed by the Local Government to watch their interests and to accompany the survey detachment, and an agent from the Maharaja of Keonjhar was also in attendance; the latter, however, was not satisfied with the boundary as relaid, and refused to sign the maps. Subsequently the Maharaja's chief agent was invited to come to Cuttack to a consultation, and he eventually agreed to a compromise, when the maps were signed in the presence of the Superintendent of the Tributary Mehals. Three tracings of the 16-inch map were prepared; one for the Commissioner of Chota Nagpore, one for the Commissioner of Orissa, and one for the Maharaja of Keonjhar.

326. The office of this party at Cuttack was inspected by the Deputy Surveyor-General in October 1890; satisfactory progress had been made in the preparation of the records.*

BURDWAN KHAS MEHALS, BENGAL.

DETACHMENT.

327. A small detachment remained to continue the cadastral survey in the Burdwan *Raj* estate, which had been commenced by a section of No. 4A. Party in season 1888-89. Preliminary traversing was started on the 20th October 1889, and the detail survey of villages traversed during the previous season, was in progress by the 7th of November.

Personnel.

Mr. J. Shaw, Assistant Surveyor, 1st grade.
„ E. F. Berkely, Assistant Surveyor, 2nd grade, from 15th March 1890.
„ F. B. Powell, Assistant Surveyor, 3rd grade, up to 20th March 1890.
5 sub-surveyors, and others.

Temporary Establishment.

150 field surveyors, and others.

328. Early in the season it became apparent that a larger area would have to be dealt with cadastrally than had been anticipated, owing to the discovery that *patnidars*, or permanent tenure-holders, in district Bankura, were in possession of much more land than was covered by their leases. Owing to a representation of this fact by the Manager, a meeting was held at the Deputy Surveyor-General's office on the 7th January 1890, at which the Director of Land Records was present, and it was decided to extend

*Mr. Patterson reports very favourably of the work performed by Messrs. R. C. Ewing, J. A. Higgs, and J. P. Barker. Of the native establishment he specially mentions,—Manohar Lall, Sheo Narain, Sabapathi, Gajadhar, Sheik Abdulla and Gurdin of the permanent list; and Abdul Aziz, Janki Pershad, Kanag Rai, Jowala Pershad, Dianidhi Das, and Kapilcharan of the temporary list.

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN THE BURDWAN KHAS MAHALS.

BURDWAN RAJ DETACHMENT.

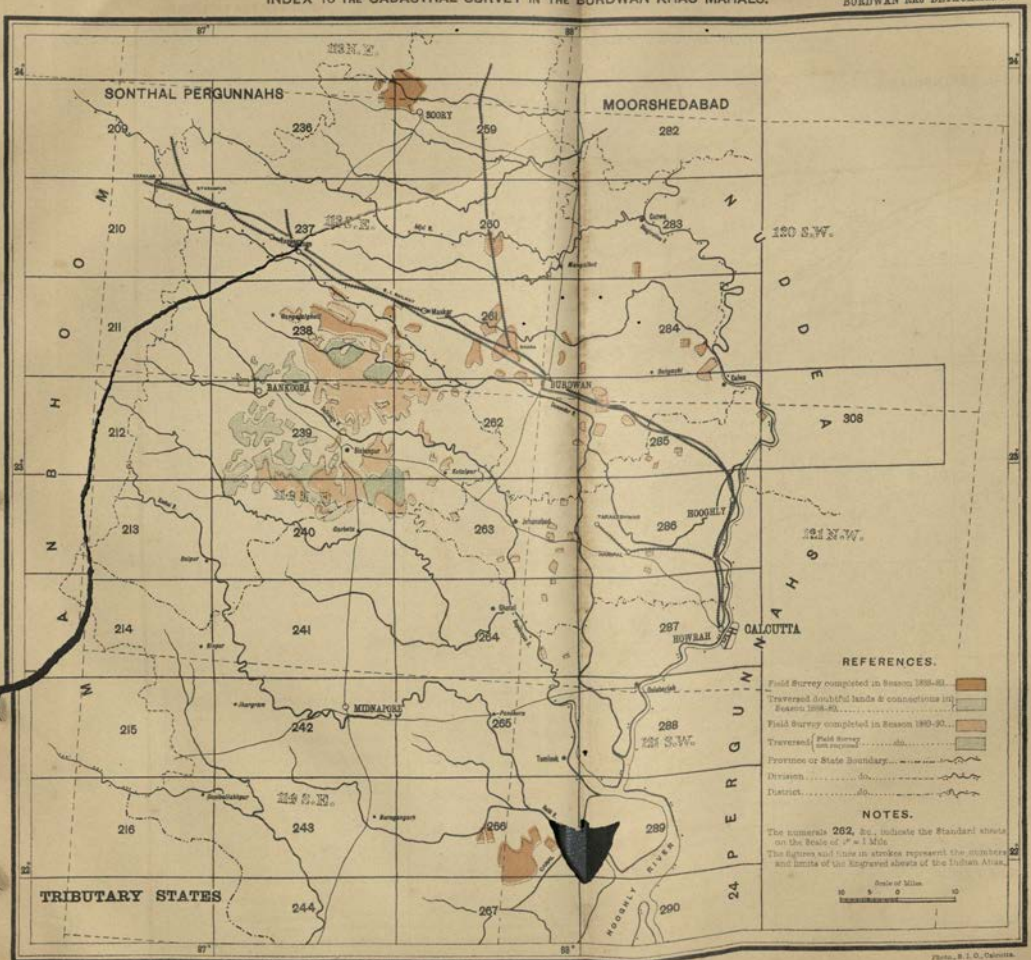


Photo., S. I. O., Calcutta.

the traverse survey to the whole of *tausi* No. 4, district Bankura. This was sanctioned by the Bengal Government and eventually carried out.

329. The traverse survey was much impeded by the want of demarcation and also by the opposition of the *patnidars* and *ghatwals*. Sub-surveyors were supplied with lists of villages obtained from the *Raj* office and ordered to traverse *mauza* boundaries on the best information they could procure locally. Subsequent examination of the boundaries surveyed during 1888-89 showed that they differ very much from those marked on the revenue survey maps of 1854.

330. In district Bankura, two main circuits have been surveyed, enclosing and connecting the *mauzas* to be dealt with. As the villages of the estate are scattered, these main circuits may be considered as merely connecting lines to fix the relative position of the *mauzas* and for the purpose of obtaining correct bearings: they are of no use for checking contained areas.

331. Of the theodolite stations in district Bankura, 632 have been marked by stones, the positions of all the others being preserved by earthen vessels filled with charcoal and buried. When some decision has been arrived at as to what are to be considered correct boundaries, it will be advisable to replace many of these marks by stones or other more permanent material, but meanwhile it would be a useless expense.

332. The following tabular statement shows the out-turn of traverse work during the season under report:—

District.	Number of villages.	Number of stations of observation.	Linear miles of traversing.	Area in square miles.
Bankura	427	7,317	1,545·48	285·80
Birbhum	10	112	17·91	1·93
Burdwan	3	102	13·90	2·52
Hugli	24	726	97·12	12·15
Nadia	1	5	1·09	0·06
Totals	465	8,262	1,675·50	302·46

333. The field survey was on the scale of 16 inches-1 = mile, and was carried out in the authorised departmental manner. The greater portion of the area surveyed is situated in district Bankura, around the towns of Sonamukhi and Bistopur. The country is undulating and consists of low copice-covered ridges alternating with highly cultivated valleys; the nature of these valleys is such that the holdings or fields have to be terraced and are consequently sub-divided into numerous small plots or *kiaris* which conform to the contour of the ground; a delineation of these *kiaris* gives a correct representation of the features of the ground. For this reason, and because it was so desired by the civil authorities, the *kiari* and not the field was made the unit of measurement. On the 16-inch sheets, however, they are distinguished by being shown in dotted lines, whilst the boundaries of fields or holdings are drawn in firm lines. The average size of the *kiari* is 0·28 acres, while that of the field including all tracts of jungle and waste is 0·89 acres.

334. Again this year the records were written in Urdu or Hindi by up-country *amins* and were translated into Bengali in office. This method is for many reasons objectionable, but experience has proved it to be the lesser of two evils and to be more economical than keeping *mohurrirs* in the field, because the Bengali is so slow and lazy and so ignorant of the use of a map that he impedes the progress of the *amin* to such a degree as to considerably effect the out-turn of work. In addition to this, Mr. Reily, the Manager of the estate, expressed his unqualified approval of the system as it will be much more difficult for the natives to tamper with the original *khasras* when written in a foreign character. The professional survey has recorded all undisputed facts regarding the tenant, his parentage, caste, and residence, methods of irrigation, crops raised, classes of soil, and uncultivated lands; but has not dealt with questions of tenure or rent, leaving these to be eventually disposed of by the Settlement officer.

335. The following table shows the season's out-turn of cadastral work:—

District.	Completed Survey in 1889-90.			Records completed and sent to Survey Office in 1889-90.		
	Number of villages.	Number of *kiaris*.	Area in square miles.	Number of villages.	Number of fields.	Area in square miles.
Bankura	323	552,129	226·93	323	124,863	226·93
Birbhum	4	449	0·65	4	449	0·65
Burdwan	21	12,827	12·93	30	35 684	26·67
Midnapur	2	5,016	2·45	28	47,908	25·67
Hugli	24	22,491	11·85	24	17,308	11·85
Nadia	1	63	0·06	1	63	·06
Totals	375	592,975	254·87	410	226,275	291·83

336. The field measurements have been checked by 639 linear miles of test survey, giving an average of 2·5 linear miles to each square mile of detail survey. There were 43,884 *khasra* entries tested out of a total of 200,059, giving an average of 4¼ per cent.

337. Besides the work noted in the preceding table, 235 villages, comprising an area of 147·30 square miles, were projected on the scale of 4 inches to the mile and the boundaries of these villages were surveyed and plotted on the spot.

338. The total cost from 1st October 1889 to 31st October 1890, or for thirteen months, has been R62,472-2-3, which gives a cost rate of 5 annas 5 pies per acre.

339. Much opposition was encountered in district Bankura from *patnidars* and *ghatwals*, who are in wrongful possession of lands of the Burdwan *Raj* estate for which they pay no rent. At one time during the operations it was expected that the assistance of the Collector would have to be called in to enable work to be carried on at all.

340. The whole of the professional records and maps were lodged in the Surveyor-General's office at the end of the recess season, and all *khasras*, tracings, statistics, &c., were sent to the Settlement Department by the 1st November 1890.

341. The recess office of the detachment at Chinsura was inspected by the Deputy Surveyor-General on the 14th September 1890 and every thing was found in good order, reflecting much credit on Mr. Shaw.*

TRAVERSE SURVEYS.

PUNJAB PROVINCE.

No. 1 Party.

342. The full strength of this party, as it stood at the close of last year, not being requisite for the work allotted to it for the year under report, it was reduced by the transfer of two assistant surveyors and six sub-surveyors and by the discharge of five temporary sub-surveyors. On Colonel Macdonald's departure on furlough, the reduced party was placed under the charge of the senior assistant, Mr. Pemberton, who has conducted the operations throughout the year.

Personnel.

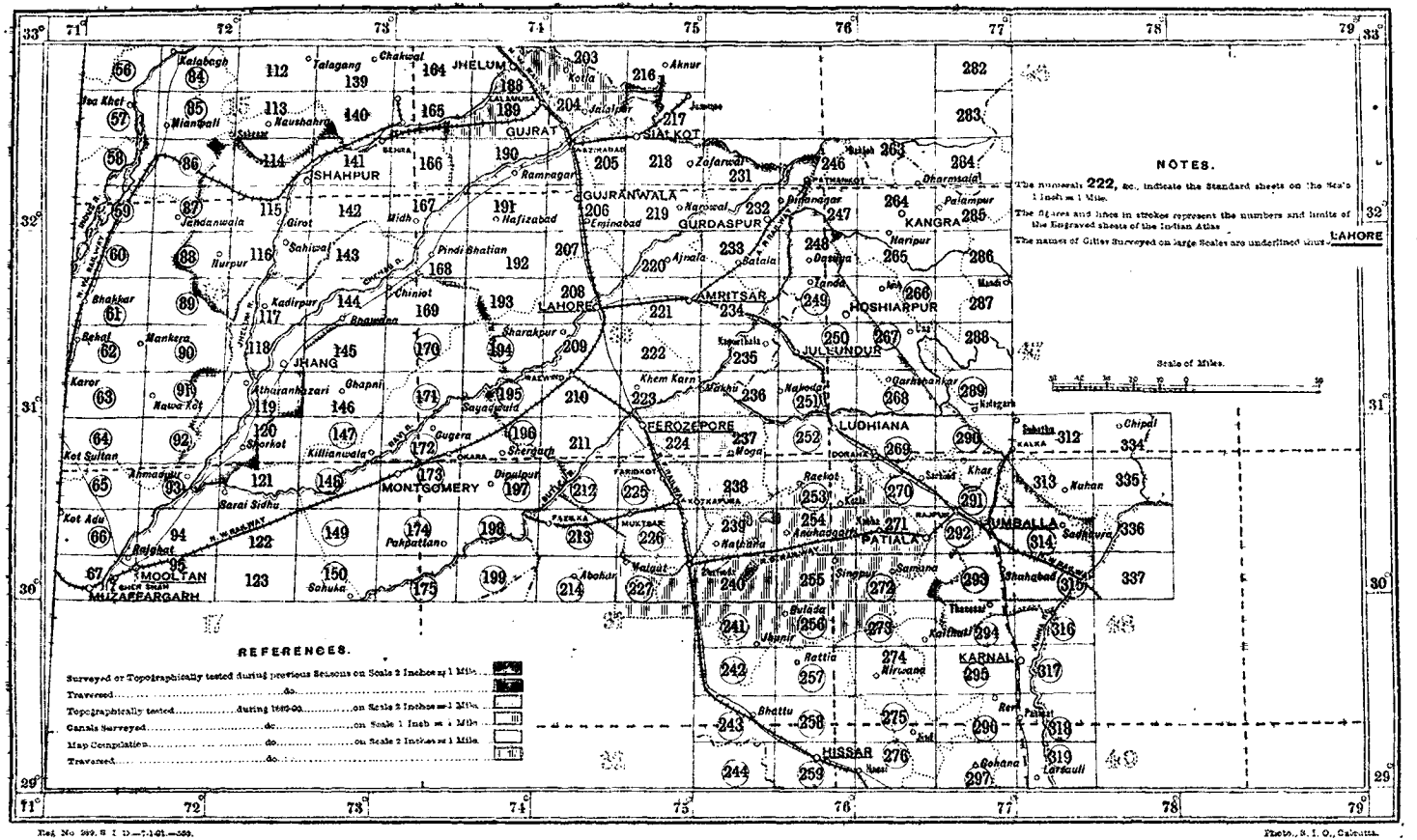
Colonel D. Macdonald, S.C., Deputy Superintendent, 1st grade, in charge up to 30th November 1889.
Mr. J. S. Pemberton, Surveyor, 1st grade, in charge from 1st December 1889.
Mr. George Campbell, Assistant Surveyor, 1st grade.
Mr. W. H. D. Ewing, Assistant Surveyor, 1st grade, up to 31st July 1890.
22 sub-surveyors and others.

* Mr. Shaw reports that Messrs. E F. Berkeley and F. B. Powell worked well during the time they were with the detachment. He also commends the following members of the native establishment:—Chunder Charan Chatterjee, Bholanath, Girdhari Lal and Roham Lal.

PUNJAB SURVEY.

INDEX TO THE SURVEY OPERATIONS IN THE PUNJAB.

No. 1 PARTY.



Ref. No. 999. S. I. O.—7-1-01.—500.

Photo., S. I. O., Calcutta.

343. The recess office at Simla closed on the 20th November 1889 and field operations were resumed shortly afterwards. For the requirements of the work the party was divided into two sections; the first section established its head-quarters at Gujrat and continued the traversing of those parts of the district which remained incomplete; the second section proceeded first to the Ferozepore district to complete the testing and correcting (where necessary) of the 2-inch mapping therein, compiled from the large scale surveys made by the Settlement Department, and then to undertake a plane-table survey on the 1-inch scale of all the canals in the Sikh states falling in sheets Nos. 227, 240, 241, 253 and 254. The survey on the 6-inch scale of the city of Lahore and cantonment of Mian Mir was also allotted to this section.

344. The following statement shows the areas completed during the season:—

Districts.	Area traversed.	Area tested, 2 inch scale.	Area topographically surveyed, 6-inch scale.	Plane-table traversing, 1-inch scale.	Area finally mapped.	
					2-inch scale.	6-inch scale.
	Sq. miles.	Sq. miles.	Sq. miles.	Linr.miles.	Sq. miles.	Sq. miles.
Gujarat	1,687	...	...	...	...	...
Ferozepore	...	1,766	...	...	1,761	...
Lahore Municipality and Cantonment of Mian Mir	...	...	72	...	...	72
Sikh States	...	...	...	3,477	...	...
Chak Andhar	...	...	...	...	...	67
TOTALS	1,687	1,766	72	3,477	1,761	139

345. The traverse operations in Gujarat, by which all the tri-junction points of villages were fixed, has been completed and the Settlement Department furnished with the direct distances between the tri-junction pillars. Owing to the very broken nature of the ground over an area of 314 square miles along the banks of the Jhelum river and of the Tawi *naddi*, the *patwâris* were unable to carry out the system of survey based on squares, which had been introduced by the late Colonel Wace, Financial Commissioner, and the Settlement Department therefore asked to have certain fixed points supplied in each village area in addition to the tri-junctions of village boundaries. The ordinary method of chain traversing could not be carried out over this area, and it was necessary to resort to the system of traversing with a subtense bar; none of the sub-surveyors being acquainted with this method, it entailed the training of the men in the first instance. This, together with the increased amount of traversing required to fix the extra points and the laborious nature of the work, rendered it necessary to keep an average of three sub-surveyors on this small area throughout the field season.

346. The test survey in the Ferozepore district has been completed; it comprised 41 field sheets and involved the chaining of about 2,800 linear miles. In connection with this 2-inch test survey, a complete survey was required of the Sutlej river where it forms the boundary between the districts of Ferozepore and Lahore, and of the junction of the Sutlej and Beás rivers, showing all the village boundaries along the former river between Ferozepore on one side and Jullundur and Kapurthala on the other. At the time of the traverse survey of Ferozepore in 1884-85, the village boundaries along the Sutlej were submerged; hence no demarcation was possible and they were not traversed; the incorporation of the village boundaries from the Settlement Department maps into the topographical maps could not therefore be made for want of common points. Unfortunately this year, although the main channel of the river had changed its course and exposed the lands in question, it was found that there were no boundary marks in existence, and so no survey of the boundaries was possible. These boundaries, however, have been inserted on the maps by building them up from the tri-junctions of adjacent villages; their accuracy, therefore, cannot be depended on.

347. The 6-inch survey of the Lahore city and Mian Mir cantonment, covering an area of 72 square miles, was also finished. It included an overlap of 31 square miles outside the municipal and cantonment boundaries, in which,

however, only such topographical items were fixed as would render possible the amalgamation of work with that being done by the Settlement Department. Village boundaries have been omitted in this survey in consequence of the imperfect demarcation; they can hereafter be entered from the settlement maps. This survey was based on the traverse stations fixed in season 1887-88, which had been marked by blocks of concrete and which were easily identified, supplemented by 29 miles of traverse run this year.

348. The 1-inch plane-table survey of canals and of village sites in their neighbourhood in the Sikh States was successfully completed. This survey had been necessitated by the impossibility of incorporating with the old surveys of the Sikh States the course of the canals as shown by the Irrigation Department in the maps supplied by them. The survey now made conclusively shows the incorrectness of the canal maps, the alterations being so great that the fair maps including these portions of country, which had already been prepared from the canal maps, will probably have to be entirely redrawn. The area covered by this survey was 3,752 square miles.

349. In addition to the work shown in the table, 49 linear miles were traversed along a portion of the Sind-Punjab boundary which had been recently demarcated, with the object of incorporating the new boundary on to the maps. A doubt having arisen as to whether the tri-junction pillar of the Sind and Punjab provinces and the Bahawalpur state, known as the Trigati pillar, had been connected with the traverses of any previous surveys, special instructions were issued for the identification and fixing of it. This was successfully done, and it was found to agree with a traverse station of one of the Dera Ghazi Khan main circuits of 1870: the doubt was occasioned by the fact that it does not appear in any of the old maps under the name Trigati. This being a most important pillar, it was very desirable to make arrangements by which the position of it might be easily ascertained without the aid of a trained surveyor in the event of its ever being washed away by the river. This was found to be impossible, as no spot which would afford a more secure position than that occupied by the pillar itself could be found within a distance of 3 or 4 miles. It has, however, been carefully connected by measurements and magnetic bearings with two adjacent boundary pillars, which the Deputy Commissioner of Jacobabad has undertaken to have permanently marked by masonry platforms.

350. During the recess, the fair mapping on the 2-inch scale of the area tested in Ferozepore, comprised in standard sheets Nos. 223, 224 and 236 to 240, was finished: this includes the whole of *tahsils* Tira and Moga and a portion of Ferozepore, and the final mapping of the whole of the Ferozepore district has now been completed. Six sheets containing the city and civil station of Lahore and the military cantonment of Mian Mir on the 6-inch scale were also fair drawn. A requisition having been received for copies of the map of Chak Andhar, a portion of country on the borders of the British and Jammu territories, of which a special 6-inch survey had been made in 1887-88 for the purpose of facilitating the settlement of disputes between the British and Kashmir cultivators as to water-rights from certain irrigation channels, it was found that the original sheets were not suitable for photo-zincography, and it was decided to redraw them rather than meet the demand by making tracings; fair maps of the 11 sheets comprising this tract of country were accordingly completed. Plots of the traverse stations on the 2-inch scale have been prepared for the whole district of Gujarat, comprised in 46 field sections. The preparation of plots of the village boundary traverses, on the scale of 24 inches to the mile, for the use of the Settlement Department was also undertaken, and 1,058 skeleton sheets were completed and have been supplied to the Settlement officer, Gujarat. The computations of the direct distances between the tri-junctions of villages over the entire area of the Gujarat district have been completed and supplied to the Settlement Department together with the data of all the traverse stations. Traverse charts or indexes to the above, comprised in 44 sheets, have also been prepared and supplied to the Settlement officer. The reduction of the fair maps to $\frac{1}{4}$-inch scale for incorporation in the atlas of India has also been completed.

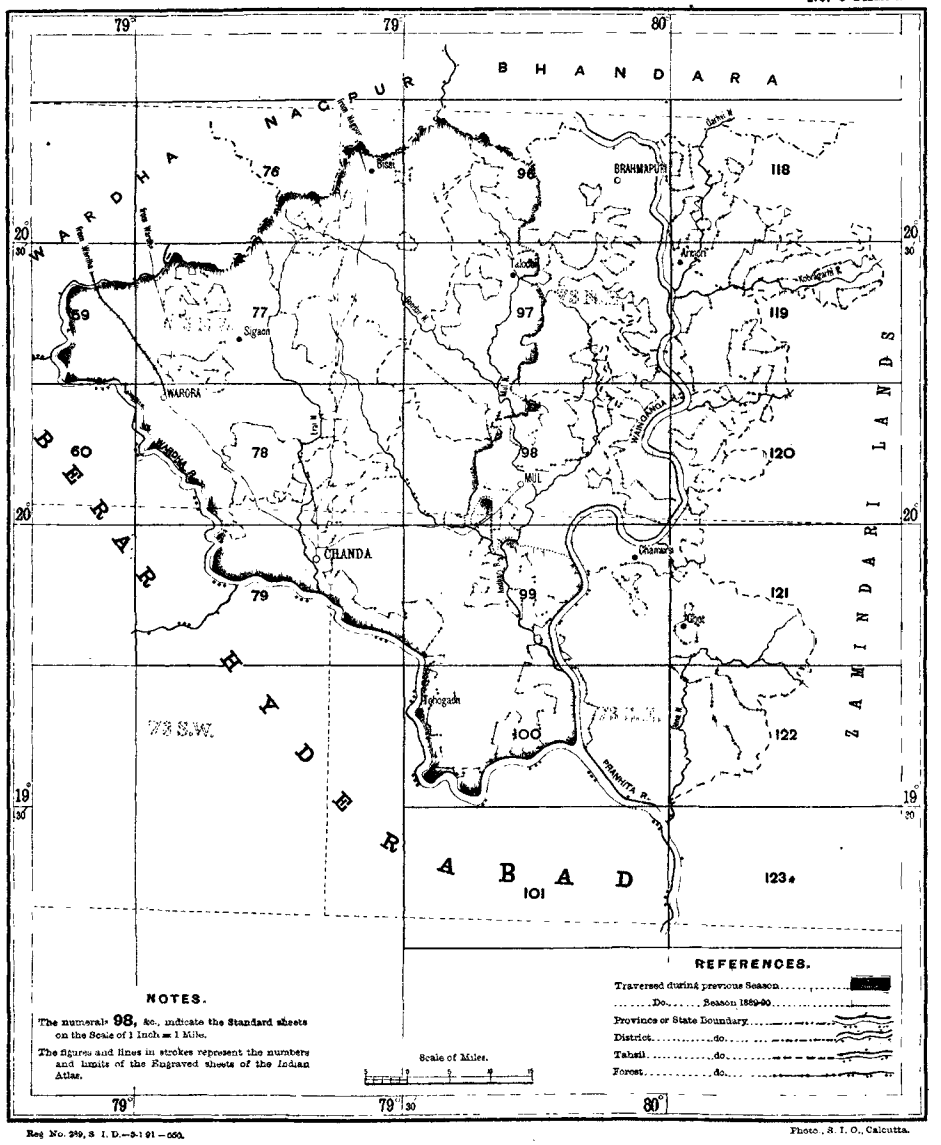
351. The recess office of the party was inspected by the Surveyor-General in October 1890, who found that the mapping and records had been very satisfactorily prepared and completed.

352. In accordance with the orders of the Government of India, this party

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICT CHANDA.

No. 9 PARTY.



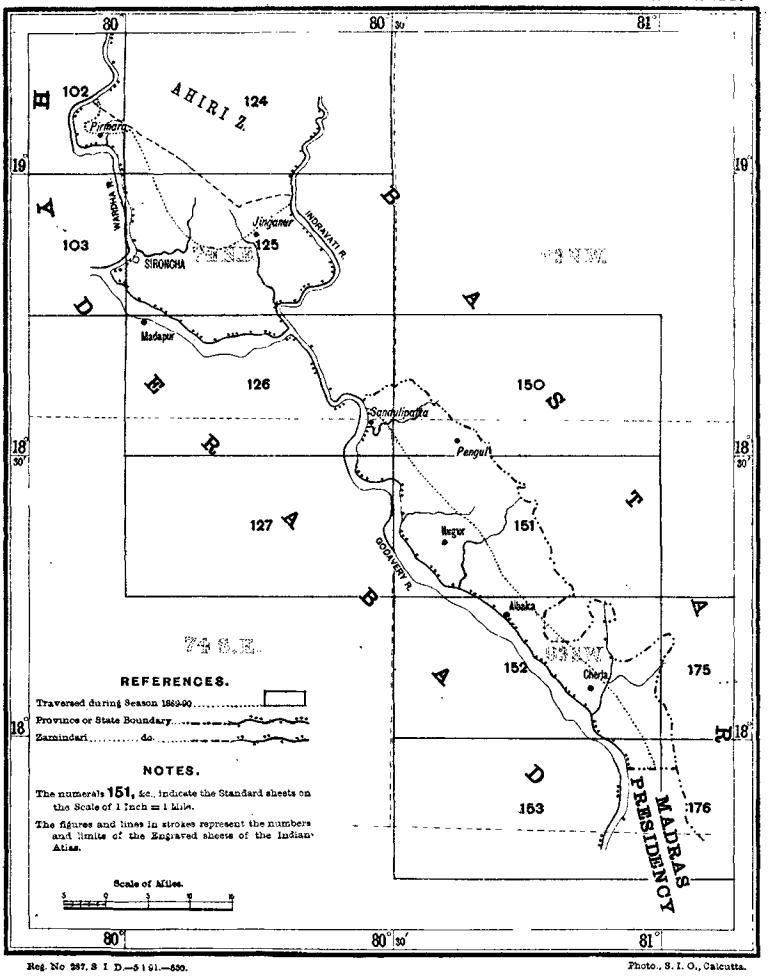
Reg No. 249, S. I. D.—3-1-91—650.

Photo., S. I. O., Calcutta.

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN SIRONCHA, DIST. CHANDA.

No. 9 PARTY.



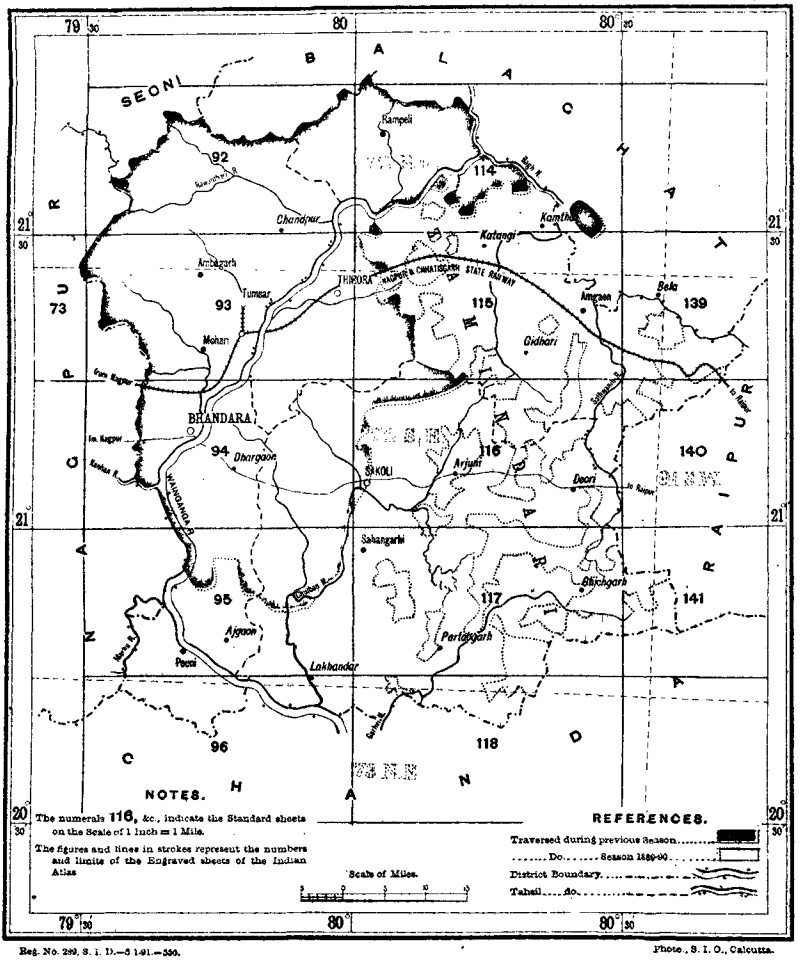
Reg. No 287, S I D.—5 1 91.—550.

Photo., S. I. O., Calcutta.

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICT BHANDARA.

No. 9 PARTY.



Reg. No. 299, S. I. D.—5-1-91.—350.

Photo., S. I. O., Calcutta.

has now been abolished and the permanent staff absorbed in other parties. A small detachment has been taken therefrom to undertake a special survey required by the Punjab Government of a portion of the Indus river where it forms the boundary between the Bahawalpur state and Dera Ghazi Khan district.*

CHANDA AND BHANDARA DISTRICTS, CENTRAL PROVINCES.

No. 9 Party.

353. This party, of the strength shown in the margin, resumed its operations in the Chanda and Bhandara districts on 5th November 1889. A portion of the Betul district, 250 square miles in area, which had been left unfinished by No. 13 Party, was also taken up, as well as the small arrears in Saugor and Balaghat which were completed. The party continued field operations in the first two districts until 1st May and in the Betul district until 1st June 1890, when it returned to its recess quarters at Kamptee.

Personnel.

Mr. G. H. Cooke, Deputy Superintendent, 3rd grade, in charge.
" H. Dowman, Surveyor, 2nd grade.
" C. W. F. Seyers, Assistant Surveyor, 1st grade, up to 15th August 1890.
" A. George, Assistant Surveyor, 1st grade.
" C. H. G. Johnson, Assistant Surveyor, 3rd grade.
40 sub-surveyors and others.

354. The traverse work in these districts has been of the same character as undertaken in previous seasons, having for its object the preparation of skeleton maps of traverse stations to serve as a basis for the detail survey of the fields by the village *patwáris* working under the Settlement officer. Wherever possible, the traverse stations have been placed on the boundary pillars, and the intermediate stations were made to follow the village boundaries as closely as possible, so as to allow of the survey of the actual village boundaries being readily plotted by offsets.

355. The Chanda and Bhandara districts have both been completed, but a certain amount of work still remains to be done in the Betul district, as the rugged nature of the country and the scattered patches of cultivation lying in jungle tracts have necessitated the running of extra traverses across the villages to enable the *patwáris* to map the detached patches of cultivation. A small area of scattered villages in jungle tracts has also to be taken up next season.

356. In the Chanda, Bhandara and Betul districts, 46,601 stones for marking survey stations were embedded along the village boundaries at a cost of 2 annas 4 pies each, or R1-14 to the square mile, including carriage and labour of embedding them. Suitable stones for these marks were found to be scarce in Chanda and Bhandara, so stone quarries had to be opened out and depôts established at certain villages where stone was procurable. As the stone quarries were situated at considerable distances from the field of operations, the Deputy Commissioners of the districts were asked to issue early orders to the *malguzars* of villages to import 30 stones each into their respective villages, which was done and this greatly expedited the distribution of the stones to the villages throughout the district in time for the field operations.

357. The out-turn of the field work is tabulated in the following statement:—

District.	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Bhandara	561	758	20,977	1,328
Chanda, including Sironcha .	944	1,173	29,496	2,608
Betul	108	132	4,865	250
TOTALS .	1,613	2,063	55,338	4,186

* Mr. Pemberton speaks in high terms of the work done by Messrs. G. Campbell and W. H. D. Ewing, who superintended the two sections into which the party was divided. He also selects the following natives as being worthy of special notice:—Elahi Buksh, writer, and Mauladad Khan, Elahi Buksh, Maula Buksh and Mahomed Akbar, sub-surveyors.

358. Connections were made with 23 stations of the Great Trigonometrical Survey to test the traverse measurements, and the angular work has been checked by observations for azimuth at 465 stations.

359. The demarcation of the villages was well done, stone slabs being erected at the bends of the boundaries and masonry platforms at the tri-junctions; these were generally found in fairly good order. Tracings from the old survey maps on the 4-inch scale, shewing the positions of all survey stations, were made and given over to the *malguzars*, who are held responsible for the safe preservation of the survey marks on the ground. The Government forest boundaries were found to be well demarcated; high piles of stones being placed at all the bends of the boundary and lines cut through the jungle from pillar to pillar. The survey marks were embedded close to the forest boundary marks, and in most cases the chain lines were run along the cleared forest lines.

360. The country traversed this season in the Bhandara district was mostly open with isolated hill ranges covered with dense jungle. In the Chanda district the greater part of the country was level but covered with dense forest jungle, which entailed much labour in line clearing. The country in the Betul district is wild and rugged and thinly populated, and much delay to the work was caused by fever of a malarious nature. The members of the party suffered a good deal from fever, ague and spleen at the commencement of the field season, especially in the Chanda district, but the sickness decreased as the season advanced.

361. Skeleton plots on the 16-inch scale, of the whole season's out-turn of 1,613 villages, contained on 2,898 sheets were prepared and have been supplied to the Settlement Department, together with the area calculations. The records for the Chanda and Bhandara districts have thus been completed.

362. The district of Mandla has been allotted to this party for traverse survey for season 1890-91; field work will be commenced early in November in two sections,—one section starting in the Mandla *tahsil* and the other in the Ramgarh *tahsil*. This is the only district of the Central Provinces which is now remaining for traverse survey. It is estimated that the survey of this district will take two seasons and will be completed by October 1892.*

PROME, HANTHAWADDY AND BASSEIN DISTRICTS, LOWER BURMA.

NO. 12 PARTY.

363. This party, having completed the main portion of its work in the Central Provinces, was transferred to Lower Burma with orders to take up the traverse survey of those portions of the districts of Bassein, Hanthawaddy, Tharawaddy, Prome and Henzada which had been omitted from the operations when the cadastral surveys of those districts were done, as well as to traverse the district of Kyaukphyu. The object of the operations is to furnish skeleton plots of traversed points to serve as a basis for the field-to-field survey to be undertaken by the survey agency under the Settlement Department. A small staff under Mr. E. F. Berkeley was left at Saugor to complete the records and to superintend the revisionary survey in the Balaghat district. The bulk of the party was transported to Burma in two batches, the first leaving Calcutta on the 29th October 1889, and the second on the 5th November 1889. On arrival at Rangoon, the party was divided into three camps, which were despatched to their several districts, *viz.*, Prome, Hanthawaddy and Bassein, without delay;

Personnel.

Mr. E. J. Jackson, Officiating Deputy Superintendent, 3rd grade, in charge.
" W. S Buttress, Surveyor, 2nd grade.
" E. G. Little, Surveyor, 2nd grade, from 1st February 1890.
" J. Connor, Surveyor, 4th grade, up to 31st January 1890.
" J. Newland, Surveyor, 4th grade, from 1st November 1889.
" P. J. Serrao, Assistant Surveyor, 2nd grade.
" T. W. Babonau, Assistant Surveyor, 2nd grade, from 22nd November 1889.
" F. S. Bell, Assistant Surveyor, 2nd grade.
32 sub-surveyors and others.

Temporary Establishment.

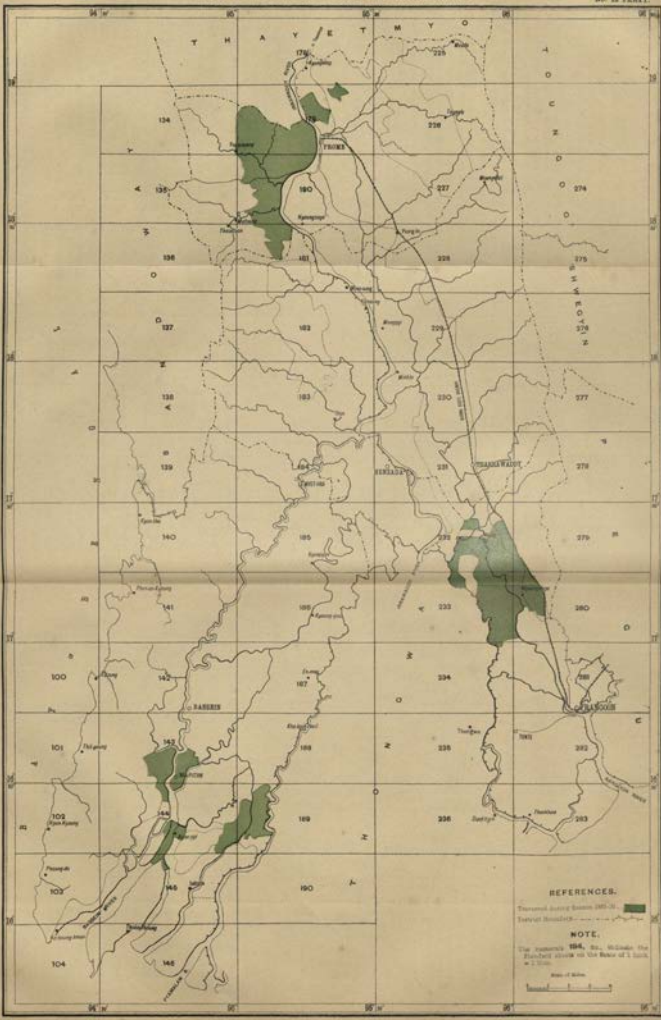
16 sub-surveyors and others.

* Mr. Cooke highly commends Mr. H. Dowman and reports very favourably of Messrs. A. George and C. H. G. Johnson. The following members of the Native establishment have merited great approval: Lall Mohun, Tara Prosonno Roy, Kesho Vaijnath, Manohar Daji and Upendra Nath Mukerjee. The following deserve to be commended:—Mr. McGowan, Narsoo Dinkar, Gopal Setaram, Peari Lall, Irfan Ali, Behar Lall, Purna Chunder Dass and Hassamuddin.

BURMA SURVEY.

INDEX TO THE TRAVERSE SURVEY IN LOWER BURMA.

No. 12 PARTY.



they were under the immediate supervision of Messrs. E. G. Little, W. S. Buttress, and J. Newland respectively; the Head-quarters camp under the Deputy Superintendent was at Prome. The whole party returned to Rangoon for the recess during the second week in June.

364. The greater part of the country surveyed in Prome lay on the right bank of the Irrawaddy river, and was hilly and covered with dense jungle, necessitating very heavy cutting and short traverse lines, which most seriously impeded the work, rendering the progress of the surveyors very slow indeed. The multiplicity of stations and consequently of the angular measurements not only increased the office work but tended to introduce errors which involved extra revisionary surveys; it also, of course, caused loss of time in embedding many more clay-pipes as station marks; in short, the work in Prome was about as difficult as any traverse work could well be, for a little more would have rendered the cost of it prohibitive. As it is, the rate, which will be found in the statement on page 84, is very high indeed, and on this point, a special report has been submitted to the Government of India. To give a means of comparing the work in Prome and Bassein, the two worst districts, with some other traverse work in Burma, the average number of stations per square mile in No. 7 Party in Lower Burma for the last five years has been calculated, and the result gives about 14¼ stations, whereas in the two districts named above there are no less than 32½ stations per mile, considerably more than twice as many. This, without including the extra line-cutting, means at least twice the labour and of course twice the expense. The areas executed in the three different districts are as follows:—

Districts.	Number of *kwins*.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Prome	274	117	11,564	380
Hanthawaddy	337	134	6,531	350
Bassein	192	200	7,011	193
Totals .	803	451	25,106	923

365. The traverse lines were, by desire of the local authorities, run as close to the *kwin* boundaries as possible, no offset being allowed of more than 1½ chains in length, except along rivers and streams where offsets of 2 chains were permitted. The strict carrying out of these rules involved extra work, as the number of stations was thereby much increased in some places. The boundaries were demarcated when necessary with posts, but as a rule natural features, such as streams, ravines, and roads, form the boundaries of *kwins*. In places where no boundaries were demarcated, such as the fisheries in Bassein and Hanthawaddy, the country was divided up into conveniently sized blocks, the traverse lines themselves being accepted as the boundaries. The maps supplied for the guidance of the traverse surveyors were very rough, not having been drawn to any scale. All traverse stations, with a few exceptions, were marked by embedding burnt clay cylinders filled with charcoal, four inches of each being allowed to project above ground. Out of the 25,106 stations fixed, 22,747 were thus marked and 740 receipts for their preservation were taken from the *kyedangyies*. At the request of the Director of Land Records and Agriculture, plots on the 4-inch scale of the traverses round the *kwin* boundaries and of the sub-traverses within were prepared in duplicate; one of these is to be retained by the *kyedangyie* of the *kwin* and the duplicate, after having been signed by him, will be lodged in the Deputy Commissioner's office for record. The orders for the preparation of these plots were not received by the District Superintendent until somewhat late in the season and so they had, in many cases, to be prepared after the traverse surveyors had left the *kwins*, but in future they will be served on the *kyedangyies* at the time of survey.

366. In the early part of the season, in addition to all the other troubles met with, there was a great deal of sickness in all these camps. At Prome, small-pox was prevalent and the Deputy Superintendent took the precaution of having every man in the camp vaccinated; one man, the writer of the party, died of that

disease; and besides this case, 19 *khalásis* died during the season of small-pox, fever or dysentery.

367. Plots on the 16-inch scale of 701 *kwins* out of the total number 803 have been supplied to the local authorities; the plots of the remaining 102 will be submitted after the traverses have been revised during the coming field season. In addition to these 16-inch sheets, plots on the 2-inch scale have been supplied to enable the Settlement Department to reduce the topography of their 16-inch work to that scale; these reduced maps will be sent to the Head-Quarters Office, Calcutta, for incorporation in the Standard sheets.

368. The programme for next season consists in the traverse survey of portions of the districts of Hanthawaddy, Tharawaddy and Henzada, which will be completed. Besides this, as much as possible will be finished in Prome, but it will not be possible to complete that district; work in Bassein is to be discontinued.*

GEODETIC.

ELECTRO-TELEGRAPHIC LONGITUDE OPERATIONS.

NOS. 22 & 23 PARTIES, ASTRONOMICAL.

369. The services of two officers being available for astronomical work during the season under review, the operations for the electro-telegraphic determination of arcs of longitude were resumed in the Punjab, Baluchistan, and Central India. Those selected for measurement form part of the general scheme for extending a net-work of longitudinal arcs over the whole of India, and include two which had been measured in the season 1885-86, but which had to be revised, owing to the discrepancies that had been shewn up by the closing of the circuits.

Personnel.

No. 22 PARTY.

Captain S. G. Burrard, R. E., Deputy Superintendent, 4th grade, in charge.
Dhondo Balwant Joshi, Computer,
Gobin Balwant Joshi, Recorder.

No. 23 PARTY.

Lieutenant G. P. Lenox-Conyngham, R. E., Assistant Superintendent, 2nd grade, in charge.
Harsahai, Recorder.

370. During the present season the programme for measuring the Baluchistan arcs afforded a convenient opportunity for the revision of these, as well as for the measurement of a cross-arc, Agra-Kurrachee, which was expected to be of much assistance in indicating the arcs to which the discrepancies were due. These three arcs, in addition to five new ones, were therefore included in the programme, which stood as follows:—

1. Agra-Mooltan.
2. Agra-Kurrachee.
3. Agra-Kalianpur.
4. Bombay-Kalianpur.
5. Jubbulpore-Kalianpur.
6. Mooltan-Kurrachee.
7. Mooltan-Quetta.
8. Kurrachee-Quetta.

Nos. 1 and 6 were the two arcs which required revision.

371. The programme, however, was not worked out in its entirety. From experiments carried out with the telescopes during the season, it became apparent that the circuit errors had not been due to any fault in the observations, and that they could be eliminated, if a new method of deducing the collimation constant were adopted: the revision of the Mooltan-Kurrachee arc became, therefore, unnecessary and it was consequently omitted. The measurement of the seven remaining arcs was carried out, and the results have proved in every way satisfactory.

372. In several previous reports the existence of errors larger than seemed consistent with the great care expended on the work, has been noticed. For instance, the sum of the two arcs Agra-Amritsar and Amritsar-Mooltan differed from the sum of the two arcs Agra-Deesa and Deesa-Mooltan by more

* Mr. Jackson reports that Messrs. E. G. Little, W. S. Buttress and J. Newland superintended the three separate camps to his entire satisfaction; the three Assistants, Messrs P. J. Serrao, T. W. Babonau, and F. S. Bell, he also reports well of. Of the Native establishment he singles out Rhedoy Chunder Dass as having worked especially well.

than half a second of time: each of these sums gave a value for the difference of longitude between Agra and Mooltan, and the two should have certainly not differed by $0^s{\cdot}10$. No one of the four arcs was believed to be more than $0^s{\cdot}02$ in error.

373. Experiments made during the season under review have shewn that Gauss's method of collimating is not suitable, in the manner hitherto employed, and that the value of the collimation constant as determined, varies with the angle that the collimators are inclined to the horizon during the process of determination. These discoveries have necessitated the introduction of a new method of deducing the collimation constant: hitherto this constant has been deduced separately for each pivot position of the telescopes from the collimated readings taken in that position only (and occasionally for each night from the collimated readings taken on that night only). By the new method, the collimation constant is for the whole arc, determined from the collimated readings taken on all the nights in both pivot positions: so that, instead of one collimated reading being used in the reduction of the transits taken in one pivot position and another being used with those taken in the other pivot position, the *same* reading is now employed in both cases. By this means the effect of any error in the determination of the collimated reading is cancelled in the mean result of transits taken in the two pivot-positions: if any real change took place in the collimated reading of a telescope, the new method would require modification; but such changes, even the smallest, cannot escape the observer's notice, and it would be an easy matter to deal with them: none have been known to occur since the telescopes returned from England in 1884.

374. The values of many of the Indian arcs are largely altered if the new method be applied to them: for instance, the longitude of Bombay east of Greenwich is increased $2''{\cdot}8$ ($=0^s{\cdot}19$) if the Bombay-Aden and Aden-Suez arcs be treated by the new method. It must be remembered that such an amount as $2''{\cdot}8$ is vastly greater than the probable error of any electro-telegraphic longitude arc, and cannot but be regarded in *geodetic work* as a large difference.

375. All the arcs of the three last seasons' work have been re-computed by the new method. The following table is given to enable the effect on the closing errors of the circuits to be appreciated. The first column gives the magnitude of the errors; the second shews the number of errors that exist of each particular magnitude when the arcs are computed by the old method, and the third column gives this number when the arcs are computed by the new method. The totals of the second and third columns shew the total number of circuits formed and are necessarily the same. What is most worthy of notice is the difference in the magnitude of the errors as given by the two methods.

Magnitude of closing errors of circuits.	Number of circuit errors of the magnitudes given in column I.	
	When arcs are reduced by the old method.	When arcs are reduced by the new method.
Larger than half-a-second of time	4	0
Between $0^s{\cdot}30$ and $0^s{\cdot}50$	2	0
„ $0^s{\cdot}20$ „ $0^s{\cdot}30$	5	0
„ $0^s{\cdot}15$ „ $0^s{\cdot}20$	3	0
„ $0^s{\cdot}09$ „ $0^s{\cdot}15$	5	0
„ $0^s{\cdot}05$ „ $0^s{\cdot}09$	3	7
Less than $0^s{\cdot}05$	4	19
Total number of circuits formed	26	26

From this table it will be seen that by the old method, eleven circuit errors exceed $0^s{\cdot}20$, whilst by the new there is not one as large as $0^s{\cdot}09$.

376. The improvement in the results of the longitude arcs, that has followed on the introduction of the new method, may also be exemplified by com-

paring the two measurements of the Agra-Mooltan arc, both of which were carried out in their entirety.

Value of Agra-Mooltan arc.	When reduced by the old method.	When reduced by the new method.
As determined in 1885-86	$26^m\ 19^s{\cdot}205$	$26^m\ 19^s{\cdot}013$
As determined in 1889-90	$26^m\ 18^s{\cdot}902$	$26^m\ 19^s{\cdot}092$
Difference .	$0^s{\cdot}303$	$0^s{\cdot}079$

Such an amount as $0^s{\cdot}303$, by which the two measurements are found to differ, when the old method of reduction is employed, is objectionable in geodetic work, and might to some extent frustrate the object with which longitude arcs have been measured in India.

377. It is also worthy of mention that in addition to eliminating the mysterious circuit errors discussed in the Annual Report of 1885-86, the new method of determining the collimation constant has been found to reduce the value of the experimental arc, alluded to in that report, from $0^s{\cdot}18$ to $0^s{\cdot}07$, and to also explain the differences that were obtained between the results by north and south stars and between the transits taken by direct and reflected vision, which could not be accounted for in the annual report of 1887-88.

378. The longitude of Kalianpur, the origin of the Great Trigonometrical Survey of India, was determined during the season under review by three electro-telegraphic arcs. Kalianpur is a small village of no political importance, situated in the territories of the Nawab of Tonk, within 3 miles of the great city of Sironj. It lies near the centre of the Indian continent, at the junction of the two chief series of triangulation, *viz.*, the Great Arc Series and the Longitudinal Series joining Calcutta and Kurrachee, and on this account it was selected in 1840 by Colonel Everest, as the origin of the Indian Survey.

379. The value adopted by Colonel Everest for the longitude of Kalianpur was $77^\circ\ 41'\ 44''{\cdot}75$ east of Greenwich, and this he obtained by computing the difference of longitude between Madras and Kalianpur through Colonel Lambton's and his own triangulation, and deducting this difference from $80^\circ\ 17'\ 21''{\cdot}00$, the then accepted value of the longitude of the Madras observatory, as determined in 1815 by moon-culminations. When the triangulation of India was finally reduced, Kalianpur was again selected by General Walker as the origin of longitude, Everest's value east of Greenwich being retained.

380. The longitude of Bombay was determined in 1877 by electro-telegraphic operations and found to be $72^\circ\ 48'\ 57''{\cdot}08$ (this value is changed to $72^\circ\ 48'\ 59''{\cdot}85$, if the new method of reduction be applied to the Aden-Suez and Bombay-Aden arcs). The new value of the longitude of Kalianpur may be thus deduced as follows:—

Longitude of Bombay	$72^\circ\ 48'\ 59''{\cdot}85$
Value of the Bombay Kalianpur arc . . .	$4^\circ\ 50'\ 21''{\cdot}61$
Longitude of Kalianpur, east of Greenwich .	$77^\circ\ 39'\ 21''{\cdot}46$

381. From this it appears that the value adopted by Colonel Everest and hitherto employed in the Great Trigonometrical Survey of India is $2'\ 23''{\cdot}29$ too large. The new value is subject to slight modification hereafter, when the whole of the longitudinal arcs in India have been measured and finally adjusted, which may cause a small alteration, probably not exceeding $0''{\cdot}2$, in the difference of longitude between Bombay and Kalianpur.

382. The new method of deducing the collimation constant is due to Captain Burrard's investigations; it is undoubtedly an improvement of considerable importance, and reflects great credit on its author. It is based on the supposition that the value of the collimated reading ($= C_o$) does not really change during the observations on any one arc, but that its apparent changes are caused by alterations in the measured quantities on which the deduced value of C_o

depends. The details of the investigations and of the season's work will be found in Captain Burrard's narrative report in the appendix.*

TIDAL AND LEVELLING OPERATIONS.

No. 25 Party.

383. The charge of the party remained in the hands of Mr. Belcham for about 2½ months, when it was taken over by Mr. C. Wood, on his transfer from the Trigonometrical Branch office, Dehra Dun.

Personnel.

Mr. Charles Wood, Assistant Superintendent, 2nd grade, in charge from 21st December 1889.
Mr G. Belcham, Surveyor, 2nd grade, in charge to 20th December 1889.
„ E. J. Connor, „ 4th „
„ J. Bond, „ 4th „

Sub-surveyors.

Narsing Das, Dhondhu Venayek, and 16 Native recorders, computers, etc.

Tidal Operations.

384. The recording of the tidal curves by the self-registering tide-gauges, their reduction, and the publication of the predicted heights have been continued as usual during the past year at seventeen stations, *viz.*, *Aden*, *Kurrachee*, Bhávnagar, *Bombay* (Apollo Bunder), *Bombay* (Prince's Dock), Cochin, Colombo, Galle, Tuticorin, *Madras*, Cocanada, *Kidderpore*, Chittagong, Akyab, *Rangoon*, Mergui, and *Port Blair*. The eight stations italicized are, with the exception of Madras, which has recently been closed for reasons set forth hereafter, *permanent* stations, where tidal registrations will be continued until the work of the minor stations herein named (and of other similar ones which remain to be taken up) is completed. The working of the minor stations is, as a rule, restricted to five years, after which the instruments are removed; but where there is either inferior work or there are interruptions, the registrations are extended for a year or so.

385. Since the date of the last report, the observatories at Colombo and Galle, having completed a six years' registration, have been dismantled; and the sites for three new observatories have been selected, *viz.*, at Trincomalee, Minicoy, and Diamond Island at the mouth of the Bassein river. The observatory at Trincomalee has been completed, and the tide-gauge and other instruments will be set up early in November; after which, the building and starting of the observatory at Minicoy will be taken in hand. The building of the observatory at Diamond Island has been committed to the Department of Public Works, and will shortly be begun: it is hoped that work will be started here next spring.

386. Besides these new observatories, it has been decided to establish an observatory at Jashk and another at Bushire, and during the coming winter these places will be visited, and arrangements made for building the observatories, so that if possible they too will be in operation next year. The arrangements referred to in the last Annual Report for starting an observatory at Shiyálbet (Port Albert Victor) in Káthiáwár, unfortunately fell through; but the Bhávnagar Darbar has, through its State Engineer, intimated that the work will without fail be taken in hand and completed this winter. The gauge for this last observatory, and all the auxiliary instruments were received about a year ago: it is of the same pattern, with improvements, as that in use at Prince's Dock, Bombay; the distinctive feature in these two being that the tidal curves are traced on drums placed vertically instead of horizontally as at all other observatories.

387. Excluding the three stations in the Gulf of Cutch, where the tidal work was inaugurated and where only a year's registrations were obtained, there are fifteen observatories which have been closed on completion of the necessary observations, while fourteen are actually in operation. Among the former is now to be included that at Madras (hitherto reckoned as a permanent station) where, from the very faulty character of the work, it was thought undesirable to continue it unless the observatory could be shifted to a more eligible spot. The question having been referred to the Madras Government, they decided to discontinue the tidal registrations, and the work there has accordingly ceased.

* Both Captain Burrard and Lieutenant Conyngham bring to notice the services of computer Dhondo Balwant Joshi, for the satisfactory execution of the works entrusted to him, and speak highly of the diligence of their observatory assistants, Harsahai and Govind Joshi.

388. All the observatories, excepting Kurrachee, have been inspected either by the officer in charge or his senior assistant; and the detailed account of the working of each will be found in the appendix. Generally speaking, the registrations have been satisfactory, but there is sensible room for improvement at Aden and Port Blair.

389. The reductions have made good progress during the year, and the out-turn is even larger than in any previous year. The observations for one year at twelve ports, and for two years at five ports were reduced,—equivalent in all to the reduction of the observations at twenty-two ports for a single year. It is not expected that high pressure in this particular direction can be maintained; and, owing to the closing of certain observatories, the reductions next year cannot possibly exceed an equivalent of nineteen ports.

390. The regular work in connection with the yearly issue of the tide tables for 1891 has been got through as usual. These tables will contain the predictions of times and heights of high and low waters at thirty-one ports, Mergui being the one that will appear for the first time.

391. The results of the predictions for 1889 may be summarized as follows:—

Percentage of predictions within 15 minutes of actuals.

	High water, per cent.	Low water, per cent.
Open coast stations	76	76
Riverain	66	59

Percentage of predictions within 8 inches of height.

Open coast stations	98	96
Riverain	70	59

These figures are very satisfactory and compare favourably with the similar statements of former years. During the year under report, the comparisons of the actual and predicted values for each of the working ports were sent home to Mr. Roberts, of the Nautical Almanac office, in sufficient time to admit of his utilizing the results for improving the predictions of 1891, where the differences showed a decided bias in any direction.

392. The usual table giving average errors of predicted times in minutes, and of predicted heights *in terms of the range*, will be found in the appendix: it is preceded by remarks explanatory of the larger differences obtained by comparison with that given in the report for 1888-89.

SPIRIT-LEVELLING OPERATIONS.

393. The levelling operations during the year under report include the following lines of double levelling:—

Section I.—From Hyderabad (Deccan) to Bezvada (in the Kistna district).

Section II.—From Novanar (Navinál), near the head of the Gulf of Cutch, to a little north of Tatta in Sind.

The total out-turn amounted to 462 miles of double levelling, in the course of which the heights of 333 permanent bench-marks and 13 stations of the Great Trigonometrical Survey have been finally determined. The apparent mean error generated in the levelling was 0·0030 foot per mile, which, considering the nature of the ground traversed by the second section, is very satisfactory.

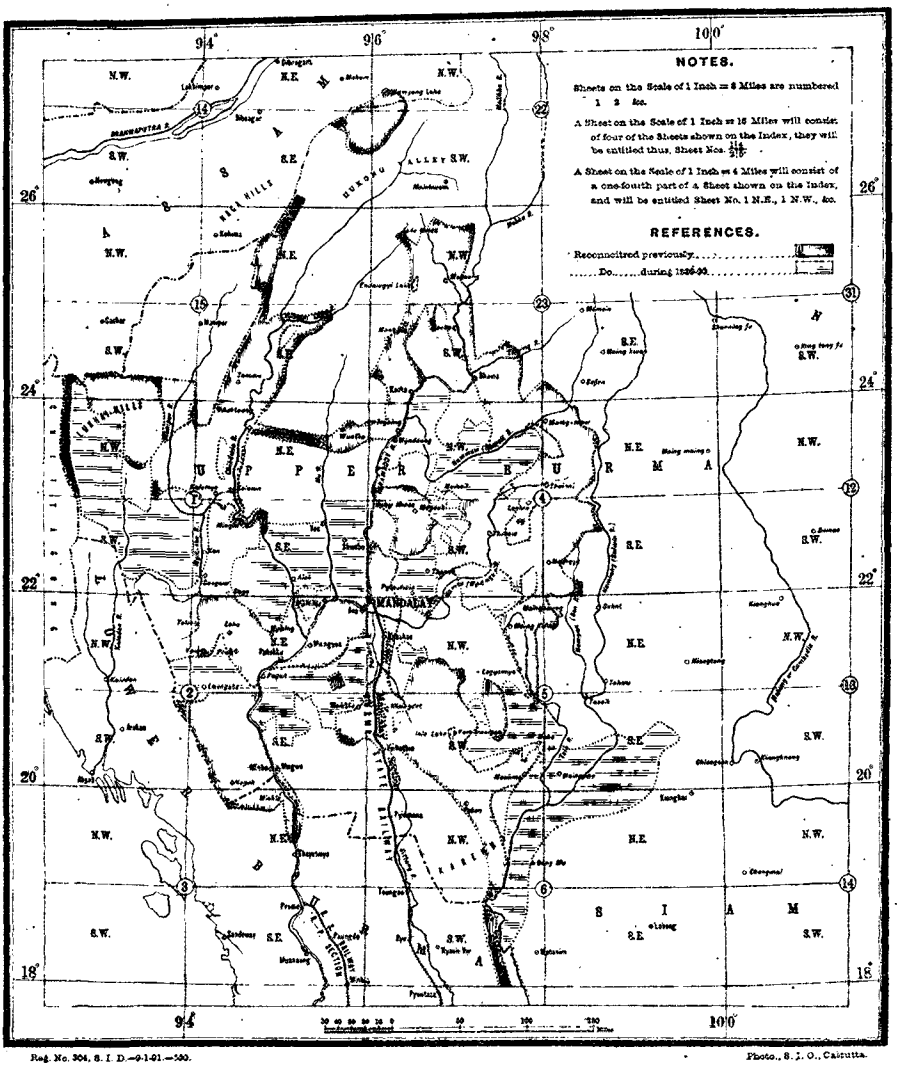
394. It is intended during the ensuing season to carry a line of levels from Rájkot to Bhávnagar and Shiyálbet (Port Albert Victor), so as to connect the tidal determinations of height at the two latter places with the general system of levels and thus complete this work in Western India. The detachment will then proceed to the Nasik district, and begin levelling from Nandgaon along the G. I. P. Railway *viâ* Nagpore: this line will furnish the means of checking, reducing, and eventually utilizing the large amount of levelling that has been already executed by the Railway Department.*

* Mr. Wood reports highly of Messrs. Belcham, Connor and Bond; the first two for work in the tidal division, and the third in the levelling section, a portion of which was carried through the Rann of Cutch, in the face of considerable physical and other difficulties, which are further described in Mr. Bond's narrative report in the appendix. Sub-surveyors Narsing Das and Dhondu Venayek have also rendered very good service; and with one exception, the Native mechanic and the other sub-surveyors, etc., have worked well.

NORTH EASTERN & SOUTH EASTERN FRONTIER SURVEY.

INDEX TO THE GEOGRAPHICAL SURVEY IN UPPER BURMA.

No. 11 PARTY.


NOTES.
Sheets on the Scale of 1 Inch = 8 Miles are numbered 1 2 &c.
A Sheet on the Scale of 1 Inch = 16 Miles will consist of four of the Sheets shown on the Index, they will be entitled thus, Sheet No. 1 1/4.
A Sheet on the Scale of 1 Inch = 4 Miles will consist of a one-fourth part of a Sheet shown on the Index, and will be entitled Sheet No. 1 N.E., 1 N.W., &c.
REFERENCES.
Reconnoitred previously.
Do. during 1899-00.
UPPER BURMA
SHAN
MANDALAY
94°
96°
98°
100°
26°
24°
22°
20°
18°

Reg. No. 304, S. I. D.—9-1-01.—500.

Photo., S. J. O., Calcutta.

GEOGRAPHICAL SURVEYS.

OPERATIONS IN UPPER BURMA.

No. 11 Party.

395. This party, having completed the traverse surveys in the three districts of Seoni, Chhindwara, and Nimar, Central Provinces, has been reorganized and sent to Upper Burma for employment on geographical surveys.

Personnel.

Captain H. M. Jackson, R.E., Offg. Deputy Superintendent, 3rd grade, in charge from 15th May 1890.
Lieutenant J. M. Fleming, S.C., Offg. Deputy Superintendent, 4th grade, in charge up to 24th December 1889.
„ C. F. Close, R.E., Assistant Superintendent, 2nd grade, in charge from 6th January 1890 to 15th May 1890.
Mr. A. J. Wilson, Surveyor, 1st grade.
„ A. G. Wyatt, do. 2nd do.
„ F. Kitchen, do. 3rd do.

Sub-Surveyors.

Goburdhun Dass, Abdur Rahman, Ramsabad Misser, Hira Singh, Sita Ram, Kudrat Ulla, and Mowni Ram.

396. Lieutenant Fleming held charge of the party at the beginning of the season, but was obliged to proceed to England on sick leave in December, when he was relieved by Lieutenant Close, a newly appointed officer, who held charge until the return of Captain Jackson from the Anglo-Siamese Boundary Commission on the 15th May, 1890.

397. The strength of the party is shown in the margin. Several of the sub-surveyors being untrained in $\frac{1}{4}$-inch work, the party was in rather a crude state for the field, and it was further weakened by having to supply hands for the Anglo-Siamese Boundary Commission.

398. The party left Rangoon on the 5th December, 1889, and took up its field head-quarters at Myingyan. The distribution of work was as follows:—Lieutenant Close, with five sub-surveyors, took up the incomplete detail survey in Myingyan and Meiktila districts. Mr. Wilson was engaged in triangulating southwards from Popa, and Mr. Wyatt northwards from Alanmyo; while Mr. Kitchen, with two sub-surveyors, was deputed to accompany the expedition to the Chinbôk country.

399. Sufficient triangulation was executed by Messrs. Wilson and Wyatt to enable the plane-table work to be satisfactorily carried out and put together, and to supply points for the beginning of next season's work to the south. Owing, however, to delay caused by Mr. Wyatt's ill-health, and to his subsequent want of judgment, the important connection with the Thayetmyo secondary series of the Great Trigonometrical Survey was not effected. This will be remedied before the commencement of next season's work.

400. The survey of the Myingyan district was practically completed, and a good deal of the Meiktila district was also mapped. The area surveyed on the $\frac{1}{4}$-inch scale, excluding that done by Lieutenant Close and Mr. Kitchen during the Baw and Chinbôk expeditions, was 3,789 square miles. Considering that the party was employed on a class of work to which it was not accustomed, this result must be regarded as satisfactory. It is hoped next season that the out-turn will be greater, the inefficient sub-surveyors having been put through a course of practical instruction during the recess.

401. During the month of April, an exploring expedition towards the Shan States of Baw, Yatzauk, etc., was arranged by the Deputy Commissioner to gain a knowledge of the country immediately touching on Kyaukse and to improve the relations with the chiefs. Lieutenant Close accompanied the expedition, as well as Mr. G. B. Scott, the officer in charge of No. 3 (Kyaukse Cadastral) Party, who remained with it for a week. After passing through the valley of the Zaogyi river, Mr. Scott turned northwards into Ye Yaman, a township of Kyaukse district, and succeeded in sketching on the $\frac{1}{2}$-inch scale an area of about 350 square miles of country, being the greater part of that wild tract. A short description of the country, with routes, was made over to the Intelligence Branch, Quarter Master General's Department. After Mr. Scott left it, the expedition proceeded southwards into the Baw State, where Lieutenant Close succeeded in mapping about 300 square miles of country on the $\frac{1}{4}$-inch scale.

402. Mr. Kitchen, who was attached to the Chinbôk expedition, left Rangoon on the 1st December, and commencing work at Pagan, proceeded down

the Irrawaddy for about 20 miles and then westwards to Pauk, eventually reaching Chaungo, the base of operations for the Chinbôk column, on the 28th January. After spending about three weeks in the Chinbôk hills, the column proceeded to Laungshe. Leaving this place on the 7th March, it proceeded down the valley of the Mon river, and turning west again, crossed the Arracan Yomas and returned to Laungshe. During the expedition Mr. Kitchen was able to survey about 800 square miles of new country. In addition to this, he obtained a further area of 1,212 square miles in the Pakokku district after the return of the expedition.

403. The main body of the party was working for the most part in cultivated and fairly thickly populated country, intersected by deep ravines near the rivers and further inland by broad, shallow water-courses emerging from that low continuation of the Pegu Yomas, which is accentuated at its northern end by the old extinct volcano of Popa. The country immediately surrounding this hill was not surveyed in detail, owing to its being still somewhat disturbed and escorts scarce. Generally, this part of Upper Burma may be said to be easy for survey as long as the atmosphere remains fairly clear.

404. The party returned to Rangoon from the field about the end of May, and the recess office opened at Bangalore on the 12th June. Captain Jackson having assumed charge of it on the 15th May, the mapping and computation of the field season's work, both of this party and of the Anglo-Siamese boundary survey, were carried on simultaneously under his supervision. At the close of the recess, the whole of this work was completed. Sheet No. 2 N.E. of the south-eastern frontier series was completed, and Nos. 2 S.E., 5 S.W., 5 N.W., 5 N.E. and 5 S.E. partially completed.

405. The programme for the next field season's work consists in filling in as much as possible of the mapping of the portions remaining unsurveyed of the sheets nearest completion, *viz.*—2 S.E., 5 N.W. and 5 S.W. The triangulation, which has already been begun, will be connected with the Thayetmyo secondary series, and carried across to Yamethin, and thence southwards towards Toungoo.

406. The total area mapped on the $\frac{1}{4}$-inch scale was 6,102 square miles, of which the particulars are as follows:—

Myingyan and Meiktila districts	3,789 sq. miles.
Pakokku district	1,212 „ „
Chinbôk country	800 „ „
Baw state	301 „ „

The area mapped by Mr. Scott in the Ye Yaman township, Kyaukse district, on the $\frac{1}{2}$-inch scale, amounted to 350 square miles.*

No. 21 Party.

407. Major Hobday supervised the field operations and continued in charge of this party until the 14th July 1890, when he proceeded to England on privilege leave, handing over charge to Lieutenant Renny-Tailyour, who held it during the remainder of the year.

Personnel.

Major J. R. Hobday, S. C., Officiating Deputy Superintendent, 3rd grade, in charge up to 14th July 1890.
Lieutenant T. F. B. Renny-Tailyour, R. E., Officiating Deputy Superintendent, 4th grade, from 18th April and in charge from 14th July 1890.
Mr. H. T. Kitchen, Surveyor, 4th grade.
„ J. M. Kennedy, Asssitant Surveyor, 1st grade.
„ C. George do. do. do.

Sub-surveyors.

Sher Shah, Faida Ali, Aladad Khan, Mahomed Latif, Ori Pandy and Mahomed Alum.

408. The operations were similar in character to those carried on during the past four seasons, *viz.*, geographical surveys on the scale of 1 inch = 4 miles.

409. The strength of the party is shown in the margin. The services of Lieutenant Renny-Tailyour and two sub-surveyors were temporarily placed at the disposal of the Military Department from the 16th December 1889 to 17th April, 1890, in order to accompany the Burma column of

* Regarding the assistants of this party, Mr. Wilson is spoken of as a very zealous, hard-working, and painstaking surveyor. Mr. F. Kitchen did good work during the field season, and doubtless had a very rough time with the Chinbôk expedition. Mr. Wyatt was somewhat handicapped by sickness, or he would probably have done better than he did.
The sub-surveyors, with one exception, are favourably reported on.

the Chin-Lushai expedition under Brigadier-General Symons, and the operations of this detachment are separately reported on.

410. On the 15th December 1889, Major Hobday, with one sub-surveyor, proceeded with an expedition despatched against the Kachin tribes south of Bhamo. After effecting its object, the expedition marched towards Manton in the Momeit state, arriving there on the 11th January 1890 simultaneously with another column coming from Momeit. On the 21st January, he joined the Momeit column which advanced to Manpun (Binbon) and thence on to Lwewein, where it remained till the 6th February, reconnoitring in various directions. From this place the column moved on to Kyungyaung in the plains. Having obtained all the topography that was possible, Major Hobday left the column on the 12th February and returned to Momeit by a new route, arriving there on the 15th. Thence he proceeded to Mogok (Ruby Mines), and finally arrived at Mandalay on the 25th February. Hearing that Mr. E. S. Carr, Deputy Conservator of Forests, was to make an extended examination of the forests in the Katha district, east of the Irrawaddy river, Major Hobday attached an apprentice sub-surveyor to his party, who succeeded in bringing in some useful work extending over an area of about 1,000 square miles, including the valley of the Shweli river, from Bahé to its junction with the Irrawaddy.

During the above operations the survey of 2,900 square miles of new country was accomplished, and an account of the journey will be found in the appendix.

411. Mr. Kitchen was employed during the months of December, January and February triangulating in a part of the Katha district that falls west of the Irrawaddy. He succeeded in fixing a number of points over an area of about 3,700 square miles, but owing to the presence of gangs of dacoits, his movements were unfortunately hampered, otherwise a larger area might have resulted. At the close of the season, Mr. Kitchen plane-tabled an area of 980 square miles in the Mandalay district and Thonzé circle of the Shan state of Thibaw.

412. Mr. Kennedy and Sub-surveyor Mahomed Latif were employed in surveying the Lower Chindwin district and completed an area of 3,300 square miles.

413. Mr. George and Sub-surveyors Alladad Khan and Mahomed Alum were employed in the detail survey of the Shwebo and Sagaing districts, and completed an area of about 2,200 square miles. The survey of the Shwebo district was completed up to the parallel of 23°, as well as of the portion of the Sagaing district that falls north of the Irrawaddy.

414. Sub-surveyor Faida Ali was attached to Lieutenant H. Daly, the Superintendent of the Northern Shan States, and completed a great deal of useful work therein, filling up many gaps in our maps between Theinni and Namkhan. At the close of the field season, Sub-surveyor Faida Ali was left at Lashio, to undertake any surveys that might be possible during the rains and to fill up certain gaps in the maps. He returned to recess quarters at Bangalore about the middle of June, 1890. His surveys extend over an area of about 3,000 square miles in the Shan states of Northern Theinni, Thibaw and Taungbaing, including also a very useful trip he made from Ngokteik (Hotök) *viâ* Nammawpilu and Namlan to Maington (Möngton) during which the courses of the Myit-nge (Namtu) and Namka rivers in that vicinity were determined.

415. The result of the season's operations by this party is as follows:—Triangulation has been carried over an area of 8,500 square miles, and the area of country that has been mapped on the $\frac{1}{4}$-inch scale amounts to 12,460 square miles in the following states and districts:—

	Square miles.
Bhamo and Katha districts and Momeit state	2,900
Mandalay district and Thibaw state	980
Lower Chindwin district	3,320
Shwebo and Sagaing districts	2,210
Northern Shan states	3,050
TOTAL	12,460*

* The European assistants with the party, Messrs. Kitchen, Kennedy and George, are favourably reported on. Regarding Mr. Kennedy, Major Hobday reports that "he is a thorough good workman in every respect. I cannot speak too highly of his qualifications, for he is both a conscientious and able surveyor and a skilled draftsman."

The native assistants with one exception are also reported to have worked satisfactorily.

OPERATIONS WITH THE ANGLO-SIAMESE BOUNDARY COMMISSION.

416. The survey party deputed to accompany the Commission appointed for the delimitation of the Anglo-Siam boundary was under the charge of Captain H. M. Jackson, R.E., and consisted of the members as given in the margin.

Personnel.

Captain H. M. Jackson, R.E., Deputy Superintendent, 4th grade.
Mr. M. J. Ogle, Surveyor, 2nd grade.
Mr. P. J. Doran, Surveyor, 4th grade.
Sub-Surveyors Mahmud Hosein, Shadi Lall, and Abdul Rahim.

417. The Commission arrived at Fort Stedman on the 1st December 1889, where Mr. Ogle was detached to work independently. He was instructed to proceed *viâ* Moné to Maingpan to survey the states of Möng-Tön, Möng-Hang, (up to the watershed between the Mekong and Salween rivers), Möng-Chut and Möng-Ta, and afterwards to work southwards to meet the Commission, who were to commence operations at the southern end of the frontier and work northwards. He was accompanied by two of the sub-surveyors. Having checked the triangulation at Moné, he carried it through Maingpan across the Salween, and then worked southwards, until he had successfully completed the survey of the four above mentioned states, and rejoined the Commission on the 25th February 1890, having accomplished the triangulation and detail survey of an area of 3,310 square miles.

418. Leaving Fort Stedman on the 16th December 1889, the main body of the Commission marched through Karenni, *viâ* Sawlon, to Yuathit, where it was divided into three parties to proceed to different points on the watershed. One sub-surveyor accompanied the southern detachment with Mr Ney Elias, the political officer in charge of the expedition ; Mr. Doran proceeded with the middle one with Mr. Archer, British Consul at Zimmé ; while Captain Jackson accompanied the third detachment with Mr. Scott, Superintendent of the Shan States. The southern and middle detachments were hurried in their movements by political considerations, and hence the surveyors were unable to connect their surveys or to obtain a very large area. The party under Captain Jackson marched up the left bank of the Salween for several days, and then turned eastwards up the valley of the Mé Sati until the watershed was reached ; here a halt was made and Captain Jackson secured a good deal of useful topography, and connected his triangulation with that done by Mr. Doran. Returning to the Salween, the party rejoined the Commission at Sadaw, the other two detachments having also rejoined it previously. Here the party was again divided ; Captain Jackson proceeded along the right bank of the Salween, taking Sub-surveyor Mahmud Hosein with him to carry on a traverse of the river, while Mr. Doran and the main body of the Commission went round by another route to reach a point whence the state of Möng-maü could be reached. Having crossed the river at different points, the two detachments met again on the left bank and the whole party proceeded to Möng-maü, where a few days' halt enabled the surveyors to map the surrounding country, and Captain Jackson to connect his triangulation with Mr. Ogle's. In the meantime the Commission had marched in an easterly direction towards Möng-Hang. Leaving the sub-surveyor behind to complete the detail survey of the country between Möng-maü and Mé Sakun, Captain Jackson and Mr. Doran followed up the main body, completing the connection of the triangulation on the ridge between the Mé Sakun and Mé Ta on the way, and on rejoining the Commission found that Mr. Ogle had arrived, after completing the work entrusted to him.

419. From this point it was decided to send Sub-surveyor Mahmud Hosein back to complete the survey of the southern portion of trans-Salween Karenni, and then to make his way southwards to Chauknyet, and on to Moulmein, *viâ* Hpapon. This work the sub-surveyor accomplished in a most satisfactory manner, and he arrived safely at Moulmein, having effected the survey of 2,670 square miles of most useful topography. His services have been recognised by the Government by a special bonus of R120.

420. Having completed their work with the Commission, Messrs. Ogle and Doran and one of the sub-surveyors were sent back to Moné by a different

route, *viâ* Maingpan, while Captain Jackson, with the other sub-surveyor, went northwards with the Commission to Möng-Hang and Möng-Tön. From the latter place Captain Jackson struck eastwards across the frontier to Möng-Sat, in order to secure the topography of that country. This done, he returned to Möng-Tön, and thence to Moné, where he overtook the Commission on the 30th March 1890.

421. The work of the Commission was now over; but as the triangulation between Moné and the Tabet valley required strengthening, and no other opportunity of doing so was likely to occur, Captain Jackson obtained permission to remain at Moné with Mr. Ogle and one sub-surveyor until rain had cleared the air sufficiently to admit of this being done, while Mr. Doran and the other sub-surveyor returned with the Commission. Rain having fallen on the 6th April, the party at once proceeded northwards to Panglong, then south through Manseik, and westwards across the Tabet valley by Banyin and completed the work required. Fort Stedman was reached on the 30th April.

422. The total area mapped during the expedition, on the $\frac{1}{4}$-inch scale, amounted to 9,620 square miles of previously unknown country. A narrative account of the operations by Captain Jackson will be found in the appendix.*

OPERATIONS WITH THE CHIN-LUSHAI EXPEDITIONARY FORCE.

423. The two columns forming the military expedition to the Chin and Lushai hills, which took place in the cold season of 1889-90, were each accompanied by a small survey detachment. The Burma column, under Brigadier-General Symons, C.B., which assembled at Kan in the Myittha valley to advance into the Chin hills, was accompanied by a party under Lieutenant T. F. B. Renny-Tailyour, R.E., and the Chittagong column, under Brigadier-General Tregear, which proceeded into the Lushai country from Chittagong, by a party under Lieutenant W. J. Bythell, R. E. Advantage was taken of every opportunity that arose for extending our geographical knowledge, and these surveys have resulted in the acquisition of the geography of about 9,000 square miles of country, of which about 5,000 square miles were totally unknown. Lieutenants Renny-Tailyour and Bythell and the surveyors of both detachments deserve much credit for the energy and ability which led to the successful issue of their labours, notwithstanding severe attacks of fever and the privations and exposure inseparable from campaigning on the Lushai and Chin hills.

424. The operations carried on by the parties attached to the respective columns will be described separately.

I.—THE OPERATIONS IN THE LUSHAI HILLS.

425. The detachment under Lieutenant Bythell, of the strength shown in the margin, arrived at Chittagong on the 22nd November 1889 and was ordered to proceed at once to Lungleh. After being detained for a short time at Demagiri for want of rations, the detachment reached Lungleh on the 9th December.

Personnel.

Lieutenant W. J. Bythell, R.E., Assistant Superintendent, 2nd grade, in charge.
Mr. W. Stotesbury, Surveyor, 3rd grade.
Sub-Surveyors Ikbaluddin and Jamaluddin.

426. Survey operations were commenced on the following day by the identification of two of the late Lieutenant Pollen's stations at Saipuya's village and Lungleh, and Lieutenant Bythell was occupied for some days in observing from these two points. Early in January, he left Lungleh and, camping at differ-

* Captain Jackson reports as follows regarding the surveyors attached to the Commission:—
"Mr. Ogle rendered, as usual, most excellent service; and whatever success may be credited to the Anglo-Siamese Boundary Survey must be credited half to him.
"Mr. Doran was most useful in assisting with the computations in the field, which had often to be done ate at night. I found him always ready and zealous to help in any way."
Two of the three sub-surveyors are also favourably reported on.

ent points on and near the new road under construction to Haka, was engaged until the 13th January in mapping in the surrounding country and extending the triangulation. Being ordered to accompany a reconnaissance to Lalthuama's village, he then made over the triangulation to Mr. Stotesbury, and devoted the whole of his time to plane-tabling and acquiring information as to the names of villages, &c., and the courses of streams. Another reconnaissance to Darbili's village enabled him to sketch in the country in that neighbourhood and to prepare several stations in advance for Mr. Stotesbury. In February, Lieutenant Bythell arranged to visit the Purun Klang, a hill 7,000 feet high, two days' march north of the Koladyne camp, from which a considerable amount of new survey could have been obtained, but he was unfortunately unable to accompany the reconnaissance there as he had received instructions to return to Darbili's village to keep up communication by heliograph with the reconnoitring party, who were to advance eastwards towards Tao and endeavour to effect a junction with the Burma column. The opportunity of visiting this peak was thus lost, and it is unfortunate that no survey officer was sent with this reconnaissance. Early in March, Lieutenant Bythell received orders to proceed to Dopura's village, and he remained plane-tabling at this place and from various camps on the Koladyne until the 26th March. During this period, his work was much impeded by heavy rain. Having received a message from Lieutenant Renny-Tailyour requesting him to meet him on the Tao Klang on 27th, Lieutenant Bythell at once proceeded thither and having met Lieutenant Renny-Tailyour as arranged, a connection of the triangulation brought up from Lungleh by Mr. Stotesbury with that done by the party with the Burma column was effected. The two officers then proceeded to Haka, which was reached on the 1st April, the survey of the country on each side of the road being accomplished *en route*. Lieutenant Bythell then obtained permission to remain with the Burma column for the purpose of accompanying a reconnaissance under General Symons proceeding from Haka for exploring the country to the south and south-west. Lieutenant Renny-Tailyour also accompanied the party which started on 5th April and returned to Haka on the 15th idem. During this excursion a considerable area of new country was mapped, and it was ascertained almost without a doubt that the Boinu river which rises a few miles north-west of Haka and flows southwards past Doong-var, subsequently turns northwards and is the main, or at least one of the main, sources of the Koladyne river. Lieutenant Bythell rejoined the staff of the Chittagong column at Haka and returned with them to Lungleh, the survey work having been practically finished.

427. The detention of the survey party at Demagiri during the advance enabled Mr. Stotesbury to survey the station and river on the scale of 12 inches to the mile. On arrival at Lungleh he assisted Lieutenant Bythell in commencing the triangulation, but was shortly afterwards attacked with fever which he did not succeed in shaking off until the 20th January. On his recovery, he took over the whole of the triangulation work in order to leave Lieutenant Bythell free to carry on the plane-table survey and to accompany the various reconnaissance parties. He carried the triangulation on successfully as far as Haka, where it was connected with Lieutenant Renny-Tailyour's series and also made surveys of Fort Lungleh on the scale of 12 inches to one mile, and of Fort Tregear on the scale of 100 feet to one inch.

428. Sub-surveyor Ikbaluddin was employed independently with the northern column, which proceeded from Lungleh to Lienpunga's village and Changsil bazar. He was instructed to sketch in as much country as he could and to return with the column to Calcutta. He succeeded in obtaining a considerable area of topography in the country traversed, which has filled up most of the gaps left unsurveyed in the first Lushai expedition of 1871-72.

429. Sub-surveyor Jamaluddin was employed in carrying a compass and chain traverse of the new road from Lungleh to Haka. This he commenced on the 13th December and carried on, as the construction of the road progressed, until it reached Haka.

430. An area of about 6,000 square miles of topography was obtained during the course of the operations above referred to.

431. The services rendered by Lieutenant Bythell and the officers who served under him have been cordially acknowledged by the General in command of the column and by the Government of India.

432. A narrative report on the operations of the detachment by Lieutenant Bythell will be found in the appendix.*

II.—The Operations in the Chin Hills.

433. The party left Rangoon on the 10th November 1889 and reached Pakokku, where the troops for the Burma column were concentrated, on the 13th November. Thence it proceeded to Kan, which was reached on the 6th December. Lieutenant Renny-Tailyour attempted to carry on a triangulation *en route* from Pauk to Kan, while Sub-surveyor Ali Nawaz Khan made a traverse of the road and Sub-surveyor Bapu Jadu was occupied in plane-tabling. Owing to heavy rain, however, very little triangulation or plane-tabling could be done at this stage.

Personnel.

Lieutenant T. F. B. Renny-Tailyour, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Sub-surveyors Bapu Jadu and Ali Nawaz Khan.

434. The column left Kan on the 16th December, and crossing the Kabè and Torsong ranges, reached Rawvan village on the 12th January 1890, and Yokwa, the capital of a large tribe, on the 18th January, the triangulation and detail survey being kept up steadily during the march. From Yokwa, Lieutenant Renny-Tailyour and one of the sub-surveyors accompanied a small party to Gangaw, which was sent to reconnoitre for a new road. In this trip a considerable addition was made to the map. They returned to Yokwa *viâ* Kan, and then proceeded to Haka, which was reached on the 18th February.

435. On the 26th February, Lieutenant Renny-Tailyour accompanied the reconnaissance to Tashon and subsequently the expedition to that place, which enabled him to connect his work with that done in the previous year about Fort White. From Tashon, Sub-surveyor Bapu Jadu was told off to accompany a small party proceeding down the Manipur or Nankathè river to Sihaung, and on his return to Haka he was again despatched with another party to Myintha. These expeditions were very useful in filling up gaps in the map.

436. On the 23rd March, Lieutenant Renny-Tailyour and Sub-surveyor Ali Nawaz Khan proceeded to Tao, where they met the survey party attached to the Chittagong column *en route* to Haka; and after connecting the work of the different surveys, Lieutenant Renny-Tailyour accompanied by Lieutenant Bythell returned to Haka, which was reached on 1st April. Thence they accompanied an exploring party under General Symons to the south-west, one object of which was to explore the Boinu river, which has been alluded to in the operations of the other column. Lieutenants Renny-Tailyour and Bythell returned to Haka on 15th April.

437. This practically ended the operations of the Burma column, and Lieutenant Renny-Tailyour returned to Mandalay *viâ* Kan and Kalewa, surveying the Myittha river from Kan to Kalemyo *en route*.

438. During the expedition an area of about 3,000 square miles of previously unknown country was surveyed, which has filled up considerable gaps in the map of that part of the country. Triangulation was extended over the whole area mapped and a fair number of distant peaks fixed.

439. Lieutenant Renny-Tailyour's services during the expedition have been duly acknowledged by the General in command and by the Government of India. A narrative account of the operations will be found in the appendix.†

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* Lieutenant Bythell reports as follows regarding Mr. Stotesbury and the sub-surveyors under his orders:—

"Mr. Stotesbury ably maintained his reputation of being a skilled observer and first-rate draftsman. He worked zealously and willingly throughout, and in spite of many difficulties carried out the triangulation most efficiently.

"From reports received from officers of the northern column I hear that Sub-surveyor Ikbaluddin was most energetic and hardworking, and accompanied all the reconnaissances from the main body. Sub-surveyor Jamaluddin kept his road traverse well up to date throughout, and worked especially hard when the road was being rapidly pushed forward from the Koladyne into Haka."

† Lieutenant Renny-Tailyour reports that both the sub-surveyors did very good work, especially Bapu Jadu, who displayed the utmost energy and zeal.

Summary of the Out-turn of Work of the

Scale of Survey.	Number of Party.	Locale of Field Operations.		TRIANGULATION.													
				Instrument used.	Area triangulated in square miles.	Number of stations at which observations were taken.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Secondary—in which each angle is usually observed on two zeros.				Tertiary—in which two angles of each triangle are observed.			
									Number of stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	Number of intersected points fixed.	Number of triangles.	Error per mile in feet.	Number of heights.
16 inches=1 mile	2	Backergunge	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Chittagong	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Tipperah	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	3	Kyaukse	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Mandalay	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	4	Jalpaiguri	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Rampur State	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Lalitpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Jhansi	...	7″	1,400	72	...	...	45	49	23	1·57	45	27	47	1·31	27
	5	Do. (Gursarai Estate)	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Kumaun Bhábar	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Tarai	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Garhwal	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Do. Bhábar	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	6	Sibsagar	15	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Nowgong	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	7	Thongwa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Amherst	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Puri	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	8	Cuttack	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Kujang	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Kanika	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Chanda	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	9	Bhandara	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Betul	25	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Bassein	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	12	Prome	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Hanthawaddy	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	13	Mergui	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	17	Bombay (Forest)	30	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Detacht.	Burdwan	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8 inches=1 mile	5	Jhansi (Forest)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	17	Bombay (Forest)	...	6″ & 7″	800	499	2·4	2·4	179	365	8·7	0·7	186	421	749	0·9	313
6 inches=1 mile	1	Lahore and Mecan Mir	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4 inches=1 mile	5	Kumaun (Forest)	35	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	7	Amherst	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	8	Kanika	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	14	Hoshangabad (Forest)	...	6″	661	120	0·9	0·9	64	182	20	0·5	96	567	1,026	0·7	567 (*b*)
	17	Bombay (Forest)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	18	Himalayas	40	12″	126	34	5	4	25	61	15	0·3	31	126	219	0·3	96(*c*)
	19	Madras (Forest)	...	42″, 5″ & 6″	970	166	2·6	2·6	150	436	18	0·4	150	285	512	0·7	277
	20	Burma (Forest)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2 inches=1 mile	1	Punjab	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	3	Kyaukse	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	10	South Maratha Country	45	12″	1,200	70	...	...	150	40	6·5	0·2	40	100	324	2·0	110
		Gujarat		10″	416	35	...	...	27	87	9	0·4	27	286	581	0·6	250
	15	Baluchistan	...	...	100	...	...	...	...	...	...	...	...	...	...	...	...
	18	Himalayas	...	12″	80	15	9	5	9	22	8	0·4	13	21	25	0·4	21
1 inch=1 mile	1	Sikh States	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	13	Mergui	50	6″	871	18	...	...	16	32	10·9	2·0	..	55	79	6·1	...
	18	Himalayas	...	7″	600(*h*)	20	30	...	...	...	...	...	...	...	...	...	...
½ inch=1 mile	3	Kyaukse (Ye Yaman)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	15	Baluchistan	...	6″	5,000	19	30	32	17	40	5·5	0·3	16	151	230	0·6	141
¼ inch=1 mile	11	Upper Burma	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	15	Baluchistan	55	6″	32,500	67	326	468	55	113	31·5	0·6	50	162	235	0·9	128
	21	Upper Burma	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Detacht.	Anglo-Siamese boundary	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	,,	Chin Hills	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	,,	Lushai Hills	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
⅛ inch=1 mile	15	Persia	60	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	24	Upper Burma	...	12″ (new)	1,205	...	...	...	...	...	...	...	...	...	...	...	...
	,,	Burma Coast	...	6″	...	16	...	...	16	13	13	...	13	...	...	...	...
	25	Hyderabad, Madras, Bombay and Sind.	63	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Totals	...	...	45,919	851	405·9	454·9	753	1440	169·1	...	667	2,201	4,027	...	1,930

Field Parties during the year 1889-90.

SPIRIT-LEVELLING OPERATIONS.				TRAVERSING.					TOPOGRAPHY.						Remarks.
Number of miles levelled over.	Number of permanent bench-mark stones embedded.	Number of Trigonometrical stations connected with lines of levels.	Number of permanent points fixed as bench-marks.	Number of stations at which theodolite was set up.	Linear miles.	Average angular error per station in seconds.	Average linear error per *mile*.	Square miles of village survey.	Area in square miles.	Average number of plane-table fixings per square mile.	Number of linear miles of test lines.	Number of villages.	Number of fields.	Average size of fields in acres.	
...	...	...	...	4,632	719	8	0·4	285	169	...	...	73	3,03,848	0·35	(*a*) Includes 34 forest reserves.
...	...	...	...	19,049	951	1	0·4	717	380	...	...	164	15,00,000	0·16	
...	...	...	...	5,193	1,264	4	0·2	318	261	...	...	283	3,39,548	0·49	
...	...	...	...	15,040	1,908	7	0·4	625	550	...	...	484	5,09,857	0·69	(*b*) In addition, 6,166 heights were determined with tangent scale clinometer.
...	...	...	...	3,103	525	9	0·2	173	...	...	...	...	...	...	
...	...	...	...	11,275	1,840	3	0·4	736	315	...	614	3,868	2,44,688	0·72	
...	...	...	...	15,624	2,728	...	...	577	66	...	401	101	49,716	0·87	
...	...	...	...	13,730	2,191	6	...	738	...	...	...	343(*a*)	...	...	
...	...	...	...	...	...	...	...	...	282	...	838	138	1,34,310	1·36	(*c*) In addition, a very large number were determined for the surveyed contour lines.
...	...	...	...	1,872	361	2	...	135	...	...	...	57	...	...	
...	...	...	...	2,102	316	...	...	309	44	...	215	149	30,196	0·92	
...	...	...	...	...	...	...	...	...	53	...	121	51	6,000	5·69	
...	...	...	...	6,660	393	...	...	300	...	...	...	565	...	...	(*d*) Tested *in situ* or by the subtense bar method.
...	...	...	...	1,359	144	...	...	16	16	...	72	56	4,183	2·45	
...	...	...	...	13,274	1,842	7	0·5	576	713	...	1,468	599	1,46,007	3·12	
...	...	...	...	15,229	3,117	3	0·3	677	1,033	...	1,153	453	4,48,713	...	
...	...	...	...	...	...	...	...	164	...	...	...	...	...	...	(*e*) Tested *in situ*.
...	...	...	...	9,310	1,468	2	...	360	360	...	851	554	3,60,043	0·35	
...	...	...	...	4,493	638	2	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	22	...	50	42	5,106	2·76	
...	...	...	...	...	...	...	...	...	262	...	1,157	565	1,92,169	0·87	
...	...	...	...	29,496	5,172	}	} 2,608		...	...	...	944	...	...	(*f*) Area tested only and maps compiled from surveys by Settlement Department.
...	...	...	...	20,977	3,539	} 5	0·6 }	1,328	...	...	...	561	...	...	
...	...	...	...	4,865	741	}	}	250	...	...	...	108	...	...	(*g*) 3,477 linear miles were traversed with plane-table to fix the system of canals spread over the area.
...	...	...	...	7,011	740	10	0·4	193	...	...	...	192	...	..	
...	...	...	...	11,564	1,091	8	0·9	380	...	...	...	274	...	...	
...	...	...	...	6,531	1,121	10	0·4	350	...	...	...	337	...	...	
...	...	...	...	...	...	...	...	28	...	...	...	20	...	...	
...	...	...	...	...	...	...	...	...	19	373	1	...	...	...	(*h*) In snowy regions, observations finished at end of year; work not yet computed.
...	...	...	...	8,262	1,675	...	...	17	255	...	...	375	5,92,975	0·28	
...	...	...	...	...	...	...	...	...	46	...	...	101	...	...	(*i*) Two verificatory azimuths were also observed.
...	...	...	...	0,124	1,435	7·6	1·0	...	335	185	235	...	...	...	
...	...	...	...	174	29	6	1·0	...	72	56	...	...	...	...	
...	...	...	...	...	...	...	...	...	300	...	30	...	...	...	
...	...	...	...	...	...	...	...	59	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	113	...	5	20	...	...	
...	...	...	...	3,837	299	21	1·5	...	495	88	164	...	...	...	
...	...	...	...	...	...	...	...	...	158	109	86	...	...	...	
...	...	...	...	...	...	...	...	...	402	45	(*d*)	...	...	...	
...	...	...	...	...	...	...	...	...	214	31	(*e*)	...	...	...	
...	...	...	...	8,060	611	17	4·2	...	169	130	54	...	...	...	
...	...	...	...	7,361	331	5·7	10	...							
...	...	...	...	10,652	3,086	9	0·5	1,687	1,766(*f*)	4	2,739	...	...	...	
...	...	...	...	...	...	...	...	...	154	...	...	...	...	...	
...	...	...	...	2,955	1,062	12	3	...	2,372	11	99	...	...	...	
...	...	...	...	...	...	...	...	...	1,600	21	155	...	...	...	
...	...	...	...	...	...	...	...	...	118	25	22	...	...	...	
...	...	...	...	...	...	...	...	...	364	15	(*d*)	...	...	...	
...	...	...	...	...	...	...	...	...	3,752	1	...	...	...	...	
...	...	...	...	1,172	91(*g*)	12·3	0·7	...	442	3	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	350	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	5,263	2·2	...	...	...	...	
...	...	...	...	...	...	...	...	...	6,102	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	35,260	0·3	...	...	...	...	
...	...	...	...	...	...	...	...	...	12,460	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	9,620	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	3,000	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	6,000	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	25,000	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Trigonometrical operations only.
...	...	...	...	34(*i*)	23	3	0·2	...	...	...	...	...	...	...	
63	462	37	13	333	...	...	...	...	...	...	...	...	...	...	
...	462	37	13	333	2,75,070	41,451	...	...	13,606	1,19,637	...	10,530	11,477	48,65,359	...

Statement showing the Cost-rates of work executed by the

Number of Party.	Nature and *locale* of Field Operations.	Cost-rate per square mile in Rupees.							
		Triangulation.	Traversing.	Detail Survey on Scales of					
				1/2"	1"	2"	4"	8"	16"
	Topographical Surveys.								
3	Kyaukse	...	...	...	...	53·1	...	...	...
10	Belgaum	6·1	2·4	...	...	17·0	...	...	...
	Gujarat	6·1	...	...	...	22·0	...	...	...
13	Mergui	35·0	50·3	...	44·9	...	...	...	...
15	Baluchistan	0·7	...	5·1	...	...	...	...	...
		...	...	...	...	133·4			
		22·0	...	...	...	...	64·4		
18	Himalayas	49·5	...	...	...	46·9	...	...	...
		5·5	...	...	...	...	...		
	Forest Surveys.								
4	Jalpaiguri	...	20·0	...	...	...	...	...	...
5	Kumaun Bhábar	...	...	...	...	...	44·5	...	...
	Jhansi	...	...	...	...	...	...	39·5	...
	Lalitpur	...	30·0	...	...	...	...	...	...
14	Hoshangabad	21·2	16·5	...	...	...	134·2	...	...
17	Bombay	35·1		...	...	...	...	110·1(*c*)	...
		...		...	...	...	84·2(*d*)	...	...
		...		...	...	...	...	...	185·1
19	Madras	28·8		...	...	...	119·8	...	...
20	Burma	...	139·6	...	...	...	354·0	...	...
	Cadastral Surveys.								
2	Backergunge	...	32·9	...	...	...	...	...	117·6
	Chittagong	...	29·4	...	...	...	...	...	175·3
	Tipperah	...	32·9	...	...	...	...	...	99·9
3	Kyaukse	...	85·2	...	...	...	...	...	206·1
	Mandalay	...	85·1	...	...	...	...	...	...
4	Jalpaiguri	...	49·6	...	...	...	...	...	135·3
5	Tarai	...	[illegible]	...	...	...	...	...	37·6(*g*)
	Garhwal Bhábar (Garhwal District)	...	[illegible]	...	...	...	...	...	50·2(*g*)
	Rampur State	...	21·7	...	...	...	...	...	98·7
	Kumaun Bhábar	...	32·0	...	...	...	...	...	94·3
	Jhansi	...	...	...	...	...	...	...	33·5(*g*)
6	Sibsagar	...	31·5	...	...	...	...	...	46·6(*g*)
	Nowgong	...	30·9	...	...	...	...	...	...
7	Thongwa	...	65·6	...	...	...	...	...	115·5
	Amherst	...	60·9	...	...	...	...	...	...
8	Kujang	...	...	...	...	...	...	...	86·5(*g*)
	Kanika	...	...	...	...	...	17·6	...	62·6(*g*)
	Puri	...	41·7	...	...	...	...	...	54·8(*g*)
	Cuttack	...	49·3	...	...	...	...	...	...
Det.	Burdwan	...	54·6	...	...	...	...	...	89·8
	Traverse Surveys.								
1	Punjab	...	11·8(*r*)	...	...	3·2(*s*)	...	...	...
5	Lalitpur	...	20·2	...	...	...	...	...	...
	Gursarai Estate, Jhansi District	...	20·3	...	...	...	...	...	...
9	Chanda	...	...	...	...	...	...	...	...
	Bhandara	...	17·8	...	...	...	...	...	...
	Betul	...	...	...	...	...	...	...	...
12	Bassein	...	144·4	...	...	...	...	...	...
	Prome								
	Hanthawaddy								

everal Field Parties during the year 1889-90.

Rate in annas for traversing, detail survey and preparation of maps.		Cost-rates.					Total cost.	Remarks.
Scale 16" = 1 mile.		Stone embedding.	Records (*Khanapuri.*)		Compilation of Vernacular Records, Assessment Statistics, &c.			
Per acre.	Per field.	Per square mile.	Per square mile.	Per field.	Per square mile.	Per field.		
a. p.	*a. p.*	*R*	*R*	*a. p.*	*R*	*a. p.*	*R*	
...	...	...	...	...	...	...	8,177	(*a*) Includes R5,679 expended on trans-frontier survey; R7,014 on plots of traverses for settlement survey; R2,774 on instruction of soldier-surveyors; R4,052 on survey schools, and R1,134 on the Kalka town survey.
...	...	...	...	...	...	...	34,199	
...	...	...	...	...	...	...	40,760	
...	...	64·5	...	...	...	...	1,03,617	
...	...	...	...	...	...	...	1,35,112	(*b*) Includes R4,045 expended on classification of forests and soils; R2,524 in bringing up arrears of mapping of Mirzapur survey. It also includes the cost of instruction of 3 soldier-surveyors and several pupils.
...	...	...	...	...	...	...	73,470 (*a*)	(*c*) Includes cost of traversing.
								(*d*) Includes cost of triangulation and traversing.
								(*e*) Includes R2,460 expended on demarcation, and R2,075 on reconnaissance surveys in hill tracts.
...	...	...	...	...	...	...	5,688	
...	...	...	...	...	...	...	13,367	(*f*) Includes R6,862 expended on demarcation, and R1,160 on mapping of 2-inch standard sheets.
...	...	...	...	...	...	...	1,798	
...	...	...	...	...	...	...	3,168	(*g*) Includes R1,905 expended on demarcation.
...	...	...	...	...	...	...	80,022 (*b*)	(*h*) Includes R4,569 expended in carrying out changes in procedure ordered by Settlement Department; R145 on completion of Basti records; R522 in instruction in survey, and R283 in traversing tea lands.
...	...	...	...	...	...	...	21,484	
...	...	...	...	...	...	...	71,049	(*i*) Includes R685 expended on triangulation; R5,367 on pay and travelling allowance of Lieutenant Crichton, under training; R1,013 on instruction of junior civilians; R1,074 on Gorakhpur mapping, and R303 on Jhansi 2-inch mapping.
...	...	...	...	...	...	...	1,07,236	
								(*j*) Includes R1,474 expended on demarcation in Sibsagar and Nowgong; R645 on Khairim-jaintia boundary survey; R2,000 on revision survey; R1,516 on survey schools, and R2,969 on 2-inch mapping.
5 3	2 3	10·6	111·2	1 0	...	...	44,928	
6 10	1 1	...	28·9	0 1	...	...	1,15,721 (*e*)	
4 10	2 5	7·0	68·7	0 9	...	...	64,203	
7 7	5 3	...	...	...	7·9	0 2	1,85,171 (*f*)	(*k*) Includes R9,723 expended on demarcation in Thongwa and Amherst; R1,769 on revision work, and R2,508 on 2-inch mapping.
...	...	...	...	...	...	...	16,628 (*g*)	
6 7	4 5	5·9	39·9	0 9	62·8	4 1	1,21,430 (*h*)	(*l*) Includes R3,228 expended on Calcutta city survey; R515 on revision survey in Puri district and Kanika estate; R479 on completion of Sankarpur records; R7,030 on completion of Angul records; R2,004 on completion of Banki records; R1,168 on 2-inch mapping of Kanika and Kujang; R2,068 on special survey of Keonjhur, Singhbhum boundary, and R3,700 on survey schools.
2 13	5 4	...	...	...	...	...	2,906	
2 3	5 6	...	...	...	...	...	2,11,[illegible]808	
3 10	2 7	...	...	...	...	...	19,020	
3 2	2 11	...	...	...	...	...	14,030	
0 10	1 2	...	15·5	0 6½	...	...	40,240 (*i*)	
2 4	7 3	...	...	...	24·4	0 7	82,843 (*j*)	
...	...	...	...	...	...	...	4,436	
4 6	6 9	...	...	...	...	...	1,84,670 (*k*)	
...	...	...	...	...	...	...	10,021	
4 1	8 3	...	50·1	3 5	0·9	...	8,598	(*m*) Includes R138 expended on demarcation.
3 1	3 4	...	33·7	0 10	1·1	...	39,774	(*n*) Includes R2,512 expended on boundary survey on 4-inch scale.
4 6	2 8	11·7	19·9	0 4	0·6	...	80,479 (*l*)	(*o*) Includes R2,209 expended on Lahore and Mecan Mir survey; R1,699 on Sind-Punjab boundary survey; R2,163 on preparation of skeleton plots of *pukki* villages in Gujrat on 24-inch scale; R2,976 on mapping on 2-inch and 6-inch scales, and R126 on mapping atlas reductions.
...	...	10·2	...	...	...	...	7,231 (*m*)	
4 3	1 2	8·1	41·5	0 3	...	...	58,875 (*n*)	
								(*p*) Includes R1,322 expended on demarcating the Chater-Pagara boundary.
...	...	...	...	...	...	...	38,818 (*o*)	(*q*) The low rate is due to the employment of local agency in lieu of imported *amins* for the field survey.
...	...	...	...	...	...	...	12,755	
...	...	...	...	...	...	...	2,737	(*r*) Traversing limited for fixing village boundary tri-junction marks.
...	...	1·9	...	...	...	...	75,769 (*p*)	(*s*) Topography not surveyed, but obtained by reduction from settlement survey maps; the reduced maps are tested in the field.
...	...	1·6	...	...	...	...	...	
...	...	...	...	...	...	...	1,33,332	× Includes Rs 2235 expended on cadastral s
								✻ Includes cost of traversing.

Abstract of Out-turn and cost of the Revenue Parties according to Jurisdictions.

Province.	Nature of Survey.	Scale of Survey.	Out-turn in square miles.	Cost.	Remarks.
				R	
Assam	Cadastral	16 inches = 1 mile	713	87,279	(a) For the Cadastral Survey by local agency under the Settlement Department. (b) Topography tested only, on maps compiled from the Settlement Survey maps. (c) Plane-table traverse survey of canals. (d) Limited to fixing of village tri-junction boundary marks.
Bengal	Cadastral	16 „ = 1 „	2,024	5,46,917	
	Topographical	4 „ = 1 „	113		
Burma	Cadastral	16 „ = 1 „	1,583	5,36,406	
	Topographical	2 „ = 1 „	134		
	Traverse	.....	951 (a)		
Central Provinces	Traverse	.....	4,186 (a)	75,769	
North-Western Provinces	Cadastral	16 inches = 1 mile	461	1,30,404	
	Forest	8 „ = 1 „	46		
	Ditto	4 „ = 1 „	300		
	Traverse	.....	738 (a)		
Punjab	City	6 „ = 1 „	72	38,818	
	Topographical	2 „ = 1 „	1,766 (b)		
	Ditto	1 inch = 1 „	3,752 (c)		
	Traverse	.....	1,687 (d)		
Total	.....	.....	18,546	14,13,593	

Particulars of Cadastral Surveys completed since 1888-89.

Districts and Estates.	Scale of Survey.	Number of Villages.	Number of fields.	Area in square miles.	Average size of fields in acres.	Cost.	Rate per square mile.		By whom and when surveyed.	Remarks.
							Traverse Survey.	Cadastral Survey, with Record of Rights and statistical statements.		
						₹	₹ a. p.	₹ a. p.		
N.-W. Provinces.										
Jhansi District	16-inch	637	6,47,950	1,440 (*a*)	1·42	77,774 (*a*)	12 10 10	41 5 3(*b*)	Col. J. E. Sandeman, during seasons 1888-90.	(*a*) Excludes 48 square miles of forest surveyed on 8-inch scale at cost of ₹2,549. (*b*) Executed by *patwári* agency only.
Bengal.										
Killa Kujang Estate	16-inch	462	1,62,913	262 (*c*)	0·89	42,475 (*c*)	51 1 10	136 13 3	Col. S. H. Cowan and W. H. Patterson, Esq., during seasons 1887-90.	(*c*) Excludes 143 square miles of jungle tracts surveyed on 4-inch scale at cost of ₹3,811.

PART III.

THE OPERATIONS AT THE HEAD-QUARTERS OFFICES.

440. These offices comprise—

1. The Head-Quarters offices at Calcutta.
2. The Trigonometrical Branch office at Dehra Dun.
3. The Drawing office at Simla.

The work in each of the Head-Quarters offices is described below:—

I.—HEAD-QUARTERS OFFICES, CALCUTTA.

SUPERINTENDENCE, CORRESPONDENCE AND ACCOUNTS.

Personnel.

Colonel H. R. Thuillier, R.E., Surveyor-General of India.
Colonel J. Sconce, S.C., Deputy Surveyor-General in charge, Revenue Branch, up to 25th October 1889.
Lieutenant-Colonel C. Strahan, R.E., Deputy Superintendent, 1st grade, Officiating Deputy Surveyor-General in charge, Revenue Branch, from 26th October 1889.
Lieutenant-Colonel M. W. Rogers, R.E., Deputy Superintendent, 2nd grade, Assistant Surveyor-General.
Mr. T. Archdale Pope, Officiating Deputy Superintendent, 4th grade, Personal Assistant to the Surveyor-General of India and Officiating Assistant Surveyor-General from 22nd July 1890.
Mr. T. W. Babonau, Registrar.

Correspondence.

Mr. M. Francis, Head Clerk.
„ E. D. Algar, do. up to 30th June 1890.
„ J. A. Vallis, Senior Examiner.
„ T. E. Ware, Clerk.
Babu Kali Podo Banerjee, Clerk, Officiating Head Clerk from 30th June 1890.

Babu Banee Madhub Banerjee,	Clerk.
„ Doorga Narain Ghose,	do.
„ Ram Kristo Chunder,	do.
„ Chuni Lal Dey,	do.
„ Bheecum Singh,	do.
„ Gopal Chunder Dass,	do.
„ Raj Coomar Dutt,	do.
Mr. E. Bonnaud,	do.

and 12 others.

Accounts.

Mr. H. H. Fenwick, Head Accountant.

Babu Bama Churn Chuckerbutty,	Accountant.
„ Raj Krishna Mukerjee,	do.
„ Hem Nath Dutt,	do.

and 5 others.

441. The general direction of these offices remained in the hands of Colonel H. R. Thuillier, R.E., Surveyor-General, throughout the year. The Revenue Branch section was under the superintendence of Colonel J. Sconce, S.C., Deputy Surveyor-General, up to the 25th October 1889, when he proceeded on furlough, and thereafter under that of Lieutenant-Colonel C. Strahan, R.E. The General and Topographical Branch sections were superintended by Lieutenant-Colonel M. W. Rogers, R.E., except for a period of 3 months when he was on privilege leave, during which time Mr. T. Archdale Pope carried on the duties.

The office of the Personal Assistant was held by Mr. Pope.*

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* The Assistant Surveyor-General reports as follows:—

Mr. T. W. Babonau, the Registrar, has carried on the general superintendence of the office in a satisfactory manner. Messrs. Francis and J. A. Vallis have also rendered good service. The clerks generally have given satisfaction, and the following are deserving of special mention:—Babus Banee Madhub Banerjee, Doorga Narain Ghose, Chuni Lal Dey, Bheecum Singh, Kanti Chunder Sen, and Raj Krishna Mukerjee. The Deputy Surveyor-General reports that in the Revenue Branch office Babu Kali Podo Banerjee, has performed his duties most satisfactorily, and Ram Kristo Chunder has done good work. Mr. E. D. Algar, Head Clerk of the section, rendered very good service until his health failed, when he was obliged to take leave from 30th June 1890. His death, which took place four months later, is much to be regretted.

DRAWING OFFICE.

442. For the first month of the year under report the Drawing office remained under the charge of Lieutenant-Colonel C. Strahan, R.E., but on the appointment of that officer to officiate as Deputy Surveyor-General, on the 26th October 1889, Major St. G. C. Gore, R.E., assumed charge of the office, and retained it for the rest of the year. The principal work of the three sections into which the office is divided is reported on below, and a detailed statement of the work executed in each section will be found in the appendix.

Personnel.

Lieutenant-Colonel C. Strahan, R.E., Assistant Surveyor-General, in charge to 26th October 1889.
Major St. G. C. Gore, R.E., Officiating Assistant Surveyor-General, in charge from 26th October 1889.
Mr. G. A. McGill, Chief Draftsman.
„ S. M. Smylie, Head Draftsman.
„ G. D. Cusson, Draftsman, from 1st February 1890.
„ W. Green, Draftsman,
„ A. J. Musgrove, „
„ J. R. Adels, „
„ R. C. Sinclair, „
„ A. S. Bateman, „
„ A. J. J. Rodrigues, „
„ E. Dowling, „
and one other draftsman.

Native Draftsmen.

Babu Harihur Sen,
„ Mohesh Chunder Shaw,
Munshi Muttiullah,
Babu Purna Chundra Sen,
„ Gopal Chunder Roy,
„ Tincowry Sen,
and 39 others.

Additional Establishment.

Mr. W. Stotesbury, Surveyor, 3rd grade, up to 31st October 1889.
„ A. J. James, Surveyor, 4th grade, from 1st November 1889,
and 7 native draftsmen.

Surveyors and Assistant Surveyors on duty.

Mr. F. Adams, Surveyor, 2nd grade.
„ W. C. Price, Surveyor, 3rd grade.
„ C. W. F. Seyers, Assistant Surveyor, 1st grade, from 16th September 1890.
„ W. H. Penrose, Assistant Surveyor, 1st grade, from 21st November 1889.
„ E. J. Martin, Assistant Surveyor, 1st grade.
„ G. D. Cusson, Assistant Surveyor, 1st grade, up to 31st January 1890.
„ S. O. Madras, Assistant Surveyor, 1st grade.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILATION.

443. As was the case last year, the preparation and publication of the maps of Burma in various forms have taxed the resources of the office to the utmost. Our geographical knowledge of that country is increasing so rapidly, that it is difficult to keep the maps up to date, as fresh editions of most of the sheets of Upper Burma are required annually. The field parties engaged on the survey prepare the fair maps on the original scale of survey, *i.e.*, 1 inch = 4 miles, but a considerable addition to the work of the Drawing office is entailed in passing them through the press, and occasionally in compiling various portions of new work to form fresh editions. To obviate the delay due to the compiling of new work on to the standard sheets, rough reproductions have been made of the field sheets executed by the officers attached to the various expeditions, and published separately in a preliminary form so as to render the work available as soon as possible.

444. The sheets of the Eastern Frontier Series, on the scale of 8 miles = 1 inch, are being completed as quickly as possible, but it has been found advisable to stop the work on some of them pending the compilation of the 4-inch sheets containing the new surveys executed last season. A first edition of sheet No. 1 of the South-East Frontier Series, containing the new work executed during the Chin-Lushai Expedition, has been brought out, and a special map of the Lushai country embracing the work done with the Chittagong column on the $\frac{1}{4}$-inch scale, as well as a reconnaissance map of the Lungleh-Haka road, on $\frac{1}{2}$-inch scale, has been published.

445. The general map of Burma, on the scale of 1 inch = 32 miles, which was published in a preliminary form in the previous year, has been completed with hills and published. It has, however, been decided to bring out a new and better edition, which in addition to containing the latest information will have the hills printed in grey, in order to render the map more legible. Considerable progress has been made with the outline already, and it is expected that the map will be published during the coming year.

446. The 24-mile map of Afghanistan has undergone various changes and additions. It has been again passed through the press, and final orders having been recently received for its publication, copies are now available for issue.

447. A third edition of the 32-mile map of India is in preparation. It differs

from the previous editions in being extended both to the east and west, so as to contain the whole of Baluchistan and Burma.

448. The skeleton Railway maps of India, on the 48 and 64-mile scales, have been corrected up to January 1890. Editions of these, with hills, have been prepared and published, having the hills shown in grey, by which means the clearness of the outlines is not interfered with. These two maps will, it is believed, be found very useful to those requiring good general maps of India, not overcrowded with detail.

449. A large amount of work has been thrown upon this section of the office, owing to the necessity of revising the whole of the standard sheets of the Mysore survey, 70 in number, due to the complete alteration of the district and *taluk* boundaries by the Mysore Government. The sheets have all been corrected and are now being re-photozincographed. The re-publication of the marginal maps of Central India and Rajputana in a complete form as full sheets has made some progress, 16 sheets having been completed. Of the 8-inch divisional maps of Bengal, four have been drawn and one is in progress. It is expected that during the coming year this series of maps will be completed.

450. In addition to the current departmental work, there has been a very large amount of miscellaneous work undertaken in this section of the office for other departments, and, as mentioned in last year's report, it is impossible with the present staff to cope with the task of keeping pace with the demands on the office. The demands of other departments are usually represented to be urgent and they have to be complied with, whatever inconvenience they may cause, and thus the progress of the departmental maps is frequently much retarded. One result of the over-pressure is that it has been found impossible to carry out the scheme initiated in 1883 for keeping the various maps up to date in regard to new public works, such as railways, canals and roads. It is much to be regretted that the standard maps of this country, on the survey and preparation of which so much labour has been expended, should have their usefulness impaired by being allowed to remain out of date for want of the necessary additions and alterations. This is in some measure, however, due to the unsatisfactory and unreliable way in which these new works are inserted on our maps by the Public Works Department, which is responsible for supplying the additions and corrections to the Survey Department, and the matter has been represented to the Government of India in the Public Works Department with a view of rectifying the present procedure.

SECTION II.—REVENUE.

451. The ordinary routine work of this section consists in examining and preparing for photo-zincography the fair maps received from the field parties of the Revenue Branch, in bringing up to date and re-publishing old maps, and in supplying data. Besides the regular work of the office, this section was engaged in drawing and completing up to margin, some of the fair topographical maps on the 2-inch scale of the Gorakhpur, Mirzapur, and Basti districts of the North-West Provinces, obtained from the cadastral surveys thereof; besides typing and finishing, as far as practicable, the fair topographical 2-inch sheets of the Kamrup and Darrang districts of Assam. It is intended, as time permits, to complete up to margin all these standard sheets throughout the survey of British India, but with the present staff of draftsmen the day is far distant when this work will be finally completed.

452. The traverse plots of the sheets of the city of Calcutta, on the scale of 200 feet = 1 inch, prepared as a basis for the reduced maps, which was commenced last year, has now been completed and the plotting examined. Progress on this map is stopped until the fair sheets of the new survey on their original scale are ready for photo-zincography, and the date of completion of this work cannot be estimated at present.

453. A map of Oudh, illustrating the occurrence of *Usar* (barren land), was also drawn on the scale of 4 miles = 1 inch for reduction by photography to the scale of 8 miles = 1 inch, in four sections, and a map of Bengal was also prepared on the 8 miles = 1-inch scale, for reproduction to scale, showing the *Reh*-affected localities. These two maps were required by the Revenue and Agri-

cultural Department of the Government of India. A map of Barrackpore and its neighbourhood was also prepared, partly from a recent riverain survey of the Hooghly, and partly from route surveys made for the purpose, for the use of His Excellency the Viceroy of India.

454. District maps of Raipur, Bilaspur, and Seonarain *tahsil*, in the Central Provinces, on the $\frac{1}{2}$-inch scale, were prepared for the Local Government, and similar $\frac{1}{2}$-inch district maps of Jaunpur, Bijnor, and Ballia have been published; those of Ghazipur are passing through the press, and those of Benares, Basti and Gorakhpur are in progress for the North-West Provinces Government.

455. The computing establishment attached to this section is very small, and the amount of miscellaneous work constantly demanding attention, such as the preparation of data for other departments, has prevented to a great extent the examination of the records of the field parties. There is, consequently, a large amount of arrears which has now been gradually accumulating, and which will require an extra staff of computers to clear off. It has been proposed to bring computers from field parties not requiring their services during the recess, to the Head Quarter's office, and three computers will be obtained during the recess of 1891 in this way. The records of only two districts, *viz.*, Kamrup and Darrang, embracing the work of two and three seasons respectively, have been examined during the year.

SECTION III.—CADASTRAL.

456. This section is employed in preparing the original maps of all the cadastral surveys for zincography and photo-zincography. The method is to examine the numbering of the fields and to observe if all holdings and divisions have been correctly tabulated in the area statements. The total number of maps passed for publication during the year was 4,407, of which 1,310 were for zincography and 3,097 for photo-zincography, showing an increase of 705 on the return of the previous year. Of the maps printed, 4,459 were coloured and sent for record with the Settlement officers of the districts to which they belonged.

The maps finally completed and published have been arranged and bound into 51 volumes for record in this office, and 40 volumes of printed cadastral maps of districts Thongwa and Bassein in Lower Burma have also been arranged in circles and townships, indexed, examined, bound, and forwarded to the Chief Commissioner of Burma.

457. The demand for printed copies of cadastral maps in the North-West Provinces continues to increase, the increase in the present year being 1,106 over last year's demands. As usual, extra copies of village maps of districts Basti and Gorakhpur have been printed for sale to the public from the depôts in those districts.

The work of examination and preparation of the maps of the current cadastral surveys for the press is greater than the small establishment kept up for this purpose is able to cope with, and thus considerable arrears have accumulated and demands for reprints can no longer be complied with, unless provision is made for the work by extra establishment.*

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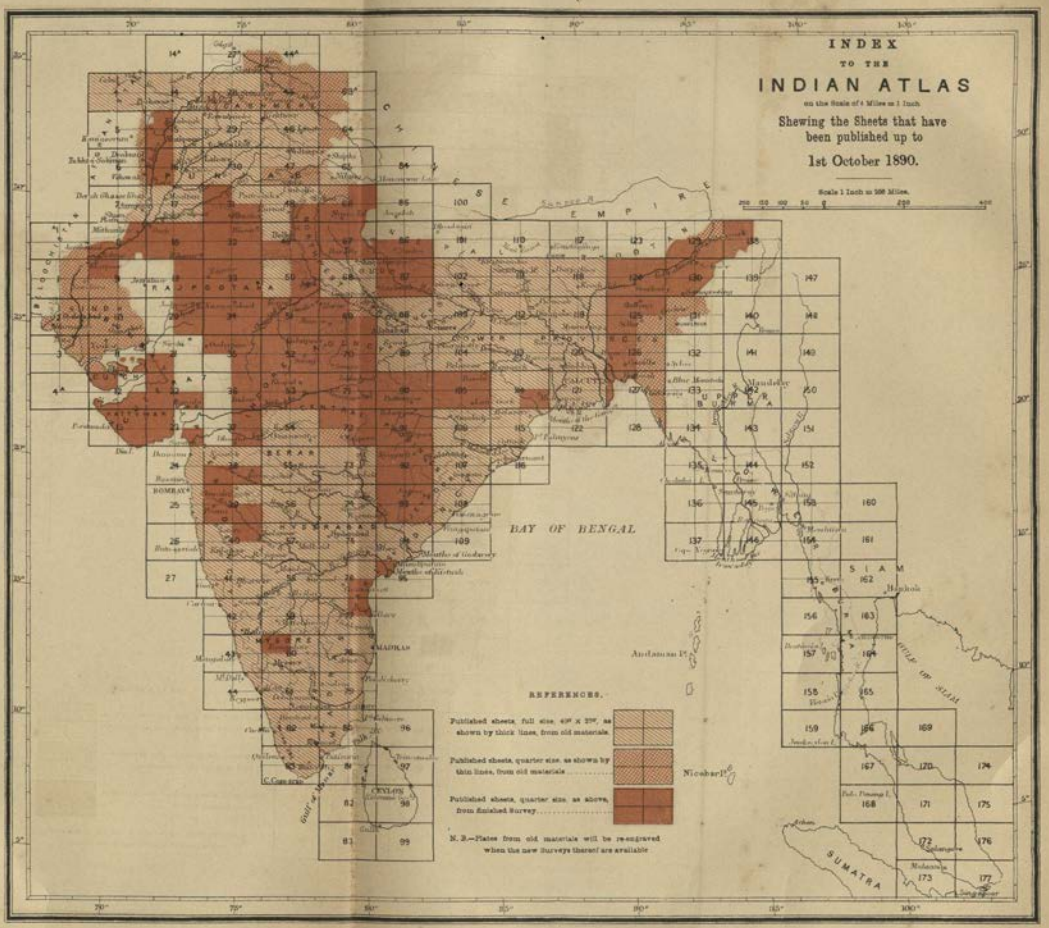
* The Assistant Surveyor-General reports as follows, regarding the Assistants in charge of the three sections, and their subordinates:—"Mr. McGill, the Chief Draftsman, in charge of No. I Section, has discharged his duties well. Mr. Smylie, in charge of No. II Section, has given the greatest satisfaction in all his work. Messrs. Adams and James, in charge respectively of the examining and cadastral sections, have supervised their establishments efficiently."

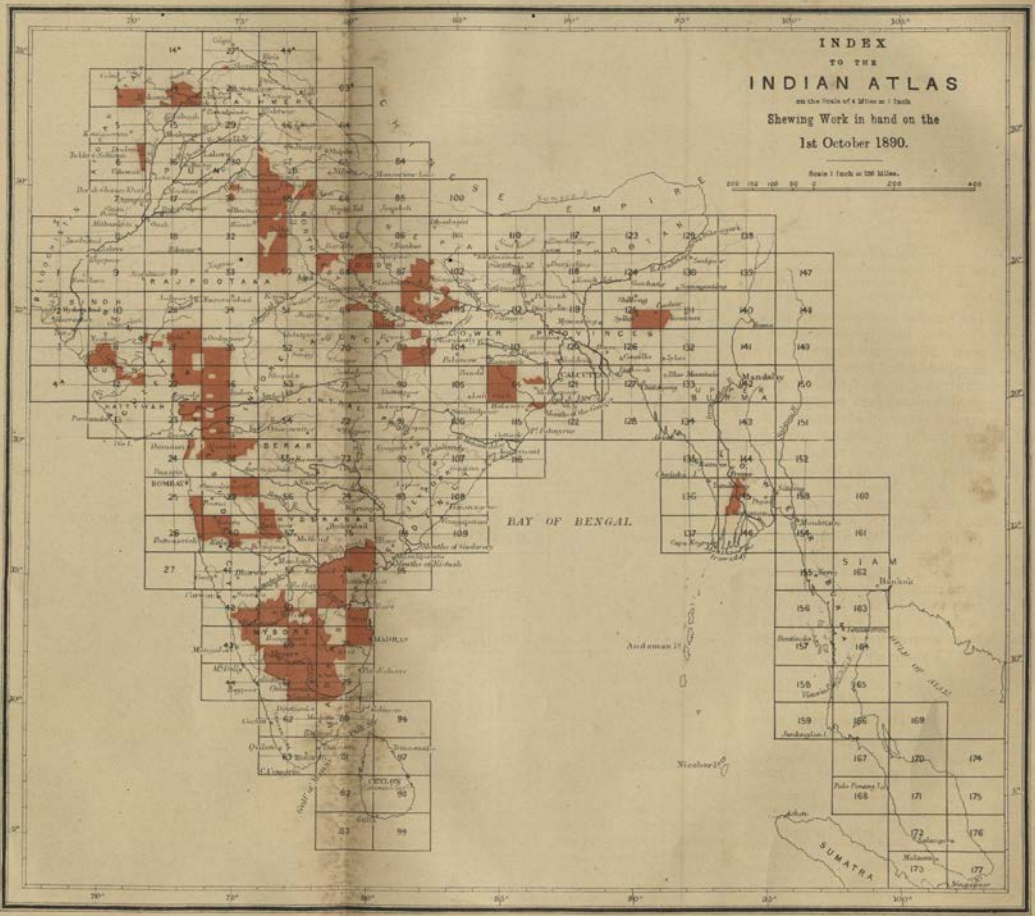
Of the European and Native draftsmen, the following are specially mentioned:—

Messrs. Green, Musgrove, Sinclair, Martin and Penrose, and Babus Mohesh Chunder Shaw, Gopal Chunder Roy, Hurihur Sen, Tincowry Sen, Ram Churn, Becha Ram Banerjee, Muttiullah, and Golam Fyek.


INDEX
TO THE
INDIAN ATLAS
on the Scale of 4 Miles to 1 Inch.
Shewing the Sheets that have been published up to
1st October 1890.
Scale 1 Inch to 100 Miles.
BAY OF BENGAL
REFERENCES.
Published sheets, full size, 40" x 27", as shown by thick lines, from old materials.
Published sheets, quarter size, as shown by thin lines, from old materials.
Published sheets, quarter size, as above, from finished Survey.
N. B.—Plates from old materials will be re-engraved when the new Surveys thereof are available
Andamans
Nicobars
SUMATRA
RAJPOOTANA
BOMBAY
HYDRABAD
MADRAS
CEYLON
SIAM

Reg. No. 4(a). H. I. D.—10-11-90.—500.

Litho., S. I. O., Calcutta.



Reg. No. 410, S. I. D.—19-12-90.—500.

Litho., S. I. O., Calcutta.

ENGRAVING OFFICE.

458. The superintendence of this office, in conjunction with that of the Drawing office, was held for different periods by Lieutenant-Colonel C. Strahan, R.E., and Major St. G. C. Gore, R.E. The supervision of the engravers has remained in the hands of Mr. G. G. Palmer, except during the three months of his absence on privilege leave, when Mr. J. Fulford acted as Head Engraver.

Personnel.

Lieutenant-Colonel C. Strahan, R.E., Assistant Surveyor-General, in charge up to 26th October 1889.
Major St. G. C. Gore, R.E., Officiating Assistant Surveyor-General, in charge from 26th October 1889.
Mr. G. G. Palmer, Head Engraver.
„ W. Donaldson, Engraver.
„ D. L. Michell, „ on furlough.
„ J. Fulford, „
„ T. B. Rodger, „
„ S. M. Coard, „
„ A. W. N. James, „
„ A. R. Coard, „
„ E. C. Ollenbach, „
„ E. Earle, „
„ L. H. Musgrove, „
„ F. R. C. Scallan, „
23 native engravers.
3 Apprentices.

Copper-plate Printing Section.

Mr. W. T. Collins, copper-plate printer.
„ A. E Pilley, assistant copper-plate printer and store-keeper.

Mr. Michell, after again extending his leave on medical certificate, was compelled finally to retire on pension on the 7th October 1890.

459. The out-turn of work is rather more than that of last year, except in the one item of hill-etching; the outline, writing, printing, and steel-facing are all in excess. The cause of the smaller out-turn of hill-etching is that the engravers usually employed thereon were required to take up more pressing work in the other classes. The number of impressions pulled exceeds by 2,000 the number pulled last year.

460. The 32-mile map of India, in six plates, is in various stages of progress: all the plates are still incomplete, as the new material that is always being supplied causes constant changes and heavy corrections, both in the duplicates and matrices. In the 64-mile map of India with railways, in four plates, the four originals have all been brought up to date, while the duplicates and matrices are in various stages of advancement. The 16-mile maps of the Punjab and Oudh are steadily advancing towards completion. In the case of the above maps, however, much still remains to be done, and it is impossible to predict when they will be finally ready for press and issue to the public. In the 96-mile map, in one plate, the original is not up to date, but the duplicate is nearly completed, corrections having been made as far as reliable material is available. This map is being engraved specially for the Railway Department, as a railway map to illustrate the administration reports thereof, and it is hoped that it will be completed by May 1891.

461. During the year, a large number of miscellaneous maps were taken in hand: among them are four new index maps for standard sheets and 19 new district maps for Administration Reports. Two Indian Atlas sheets on the $\frac{1}{4}$-inch scale have been published; 39 have had additional material engraved, and 46 have been corrected. In all, 232 plates have been worked upon during the year.

A summary of the work performed will be found in the appendix.*

CALCUTTA CITY SURVEY OFFICE.

462. During the year, the establishment employed on this undertaking has been disconnected from the field party to which it had been attached, and placed under the charge of the Assistant Surveyor-General, Drawing Office, Calcutta, in addition to his ordinary duties. The work under review was therefore done under the supervision of Major St. G. C. Gore, R.E., up to the 22nd September, when he was transferred and Colonel Wilkins took over charge.

Personnel.

Major St. G. C. Gore, R.E., Deputy Superintendent, 4th grade, in charge, to 21st September 1890.
Colonel W. H. Wilkins, S.C., Deputy Superintendent, 2nd grade, in charge, from 22nd September 1890.
Mr. D. Atkinson, Surveyor, 1st grade.
„ A. B. Smart, Assistant Surveyor, 2nd grade.
Babu Sarat Chunder Sen, Assistant Surveyor, 3rd grade, from 26th August 1889 to 1st December 1889.
Three draftsmen, one computer, and others.

Temporary Establishment.

27 draftsmen.
4 field surveyors, and others.

463. The out-of-door work during the year has consisted almost entirely in ascertaining and laying down the boundaries of registered holdings; the total number laid down up to the end of September

* Mr. Palmer has continued to supervise the office in a most efficient manner, and the European engravers have all worked satisfactorily. The native engravers are also on the whole well reported on.

amounted to 17,401, the number added during the year being 4,421. The prosecution of some of the absentee proprietors for failing to attend after due notice had been served on them has resulted in some good, but still great delay is caused by the non-attendance of proprietors, the number of absentees amounting to 6 per cent. of those to whom notices were issued.

464. Out of 459, the total number of field sheets, 257 have been coloured; in many instances it was found necessary to examine details on the spot in order to ensure their being correctly coloured. The re-survey of the places where new buildings have been erected since the survey was made has only been effected where the correct insertion of boundaries necessitated it.

465. The inking in of the fair maps, 235 in number, has been completed as far as possible, but none can be entirely completed until all the boundaries falling in each map are finally passed. During the year, there were 249 disputed boundaries, among which claims were entered in only 174 cases. The Assistant Superintendent of Survey under the Calcutta Survey Act, Babu Kally Charn Ghose, decided 141 of these cases, the remaining 33 being still under investigation.

466. The survey of the boundaries has been carried on systematically from the southern towards the north-western portion of the city; all those properties of which the proprietors were present were demarcated, but the properties of absentees had to be left for future survey. These omissions are scattered all over the city of Calcutta, and the survey of them will be taken up systematically from the southern end, as soon as the bulk of the boundaries left towards the northern portion have been settled, which will probably be by the end of March 1891. The boundaries of Government House, the Bengal Secretariat, the *maidan*, the Military Department buildings in Hastings, and the lands belonging to the Port Commissioners all require to be demarcated.

467. The following work still remains to be completed:—

(1) The house-to-house enquiry as to names and addresses of proprietors, and the investigations of the boundaries of holdings, of which there are probably 200 remaining in the Collectorate and about 2,500 in the Sutanoti *taluk* of Calcutta.

(2) The completion of the original field sheets in colour, which involves many references to the spot, and in some cases re-surveys in consequence of additions or alterations since the original survey was made.

(3) The survey and adjustment of the boundaries of about 1,500 holdings of which the proprietors were not present at the time of survey.

(4) The completion and publication of 235 fair sheets, all of which are in various stages of completion and are only waiting for the demarcation and insertion of all the boundaries.

(5) The completion of the register of proprietors.

468. It is impossible to foretell the date of the publication of the last sheet of the Calcutta survey. The causes of delay are not under the control of the Survey Department; they are due solely to the absence of the proprietors when the surveyor requires to lay down the boundaries. Summonses are unattended to, and as it is absolutely necessary for the validity of the boundaries shown on the map that the proprietors should be actually present when they are being surveyed, more stringent measures are required to enforce attendance.*

* Mr. D. Atkinson, who was in immediate charge of the office, has performed his duties always to the satisfaction of the superintending officer. The investigation of boundaries has been in a great measure carried out by him. Mr. A. B. Smart has worked with great energy and zeal; he is a very deserving assistant.

Mr. Atkinson mentions very favourably Gunga Bishen, computer, and Rahim Buksh, draftsman, and states that all his establishment generally have worked well.

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE.

469. At the beginning of the year, Mr. T. A. Pope officiated in charge of the office until the 5th December, when Colonel J. Waterhouse, S.C., returned from leave and resumed the charge which he held for the rest of the year. After being relieved, Mr. Pope was transferred for duty in the Surveyor-General's office and did not return to this office during the year.

Personnel.

Colonel J. Waterhouse, Assistant Surveyor-General, in charge from 5th December 1889.
Mr. T. A. Pope, Officiating Deputy Superintendent, 4th grade, in charge up to 5th December 1889.

NEGATIVE SECTION.

Normal Establishment.

Mr. H. Haward, Head Assistant, in charge.
„ G. G. Dempster, Photographer, up to 18th December 1889.
Ismail Khan, Assistant Photographer
Mr. G. W. Mackie, Photographer.
„ E. Savedra, Apprentice.
One assistant photographer and two negative re-touchers.

Cadastral Establishment.

Mr. C. Marshall, Photographer, up to 1st May 1890.
Mr. L. Lagnier, Photographer.
„ T. Lloyd, Officiating Photographer.
„ C. DeCruze, Assistant Photographer.
Three assistant photographers and three negative re-touchers.

PHOTO-TRANSFER PRINTING SECTION.

Normal Establishment.

Mr. J. Harrold, Photographer.
Habibul Hossain, Assistant Photographer.
Mr. P. C. Michael, Apprentice.

Cadastral Establishment.

Mr. R. George, Photographer, and two assistant photographers.

SILVER PRINTING SECTION.

Mr. C. J. Meade, Apprentice, and one assistant photographer.

HELIOGRAVURE AND COLLOTYPE SECTION.

Mr. A. W. Turner, Photo-engraver.
„ P. Mackenzie, Apprentice.
One assistant photographer, two engravers and three copper plate printers.
Mr. J. T. Meade, Collotype Printer.

LITHOGRAPHIC DRAWING SECTION.

Mr. H. L. Lepage, Head Assistant.
Babu Umbica Churn Mookerjee, Examiner.
Munshi Sobhan Bakhsh, and 24 others, draftsmen.
Mr. E. Dowling, Apprentice, up to 12th May 1890.

ZINC-PRINTING SECTION.

Normal Establishment.

Mr. B. Mackenzie, Zincographer, from 7th January 1890.
„ F. R. Vandyke, Zincographer.
„ J. B. Mackenzie, Assistant Zincographer.
One writer and four zinc correctors.

Cadastral Establishment.

Mr. J. Watson, Zincographer, 7th January 1890.
„ E. A. Le Franc, Zincographer.
„ G. A. Le Franc, Apprentice.
One writer and nine zinc correctors.

LITHO-PRINTING SECTION.

Mr. D. Deas, Head Lithographic Printer.
„ S. U. Ravenscroft, Assistant Lithographic Printer.

TYPE-PRINTING SECTION.

Mr. E. DePyvah, Head Type Printer.

CORRESPONDENCE AND ACCOUNTS SECTION.

Normal Establishment.

Mr. W. Moore, Storekeeper.
Babu Kanny Lal Sen, Clerk and Accountant.
Babu Gopal Chunder Mookherji, Clerk, and one other.

Cadastral Establishment.

One clerk.

LITHOGRAPHIC ESTABLISHMENT.

Babu Russick Lall Shaw, Clerk, and five others.

470. There have been few changes in the establishment during the year. Mr. B. Mackenzie, Head Zincographer, returned from furlough on the 7th January, and Mr. J. Watson, zincographer, retired on superannuation pension from the same date after an excellent service of 22 years in the office. As stated in last year's report, arrangements have been made for filling the vacancy by the appointment of 2nd Corporal F. Vandyke, R.E., from the Queen's Own Sappers and Miners, who has done useful work on the new large zinc-printing machine and has been transferred permanently to the Survey Department after completing a year's probation. Mr. C. Marshall, photographer on the cadastral establishment, broke down in health in May 1889, when he was obliged to take furlough to Europe on medical certificate. As he attained the age of 55 on the 21st of July 1889, he retired from that date on a superannuation pension, after good service in the office of 13 years. Mr. G. Dempster, photographer on the normal establishment, died on the 18th December 1889. Mr. E. Dowling, apprentice in the Lithographic Drawing section, was transferred to fill a vacancy in the Drawing office.

471. The new steam machinery was started in May 1889, though work with the large lithographic machine was not commenced till July, owing to additional support for the shafting being found necessary. Since that time all the machines have been constantly at work with scarcely a hitch or difficulty, and they have enabled the office to turn out an amount of work which could not possibly have been dealt with without their aid, both in the Lithographic and Zinc-printing and Type-printing sections. So far as present experience shows, there seems to be ample work for all the hand-presses as well as the machines.

472. Further experience has proved that the new office buildings are very convenient and well suited for the purpose. The work in all sections is carried

on with far greater efficiency and comfort than was possible in the old offices and the superintendence has been considerably facilitated and made more effective. The large printing room was found to be hot for the zinc-printing on the upper floor during the hot weather, and it was found necessary to revert to the old system of early hours from April to June 1889; but no difficulty was experienced in the lithographic printing on the ground floor. The principal photographic dark rooms have been efficiently ventilated, so that all fumes of collodion and other chemicals are quickly carried off; especially in the hot weather, when a good current of air is found to constantly pass through the rooms. The quadrangular form of building has been found to provide a good circulation of air throughout the building.

473. The general abstract of work turned out, given in the tabular statement below, shows a very considerable increase in all sections over the out-turn of the previous year. The only large falling off is in the number of pulls in the type-printing section; this may be partly accounted for by the large type machine being out of work for some days during its transfer from the Mathematical Instrument office to the new building; but, as will be seen, the real work of this section has been about half as much again as last year. The number of silver prints has also fallen off; but, on the other hand, there has been a very large increase in the number of blue prints which are now largely used as proofs in order to avoid locking up zinc plates unnecessarily during the sometimes lengthy process of examining new standard sheets. A comparison of the work of the year under report with that of the preceding year is also given in the table.

General Abstract of Work done during 1889-90.

Specification of Plate or Print.	Photozincographic and Lithographic Printing.										Type Printing.			Silver and other Printing.		Heliogravure and Electrotyping.				Photo-collotype.		Value.
	Sheets or Subjects.	Negatives and transparencies.	Photo-transfer Prints.	Zinc Plates transferred.	Zinc Plates printed.	Stones.	Pulls.	Number of Copies. Coloured.	Uncoloured.	Total.	Pages or items.	Pulls.	Copies.	Silver Prints.	Blue Prints.	Heliogravure Plates.	Heliogravure Prints.	Photo-Blocks.	Electrotypes.	Photo-collotype Plates.	Photo-collotype Prints.	
Departmental maps, plans, &c.	1,211	1,308	945	316	360	165	162,379	25,890	109,760	135,650	9,918	1,061,577	573,885	54	2,645	19	2,417	6	17	...	60	£ 69,618 13 3
Cadastral maps	4,548	3,241	3,230	4,499	4,499	...	108,799	...	99,354	99,354	...	...	...	...	...	...	...	...	...	...	...	60,817 7 3
Extra-departmental maps and plans	1,262	1,051	973	562	681	420	327,819	73,163	354,536	427,699	...	...	...	125	178	37	28,172	...	...	12	3,372	69,938 8 9
Total	7,021	5,600	5,148	5,377	5,540	585	598,997	99,053	563,650	662,703	9,918	1,061,577	573,885	179	2,823	56	30,589	6	17	12	3,432	200,374 12 6
Total of 1888-1889	5,540	4,796	4,513	4,349	4,285	447	579,964	53,933	591,678	645,611	6,646	1,177,175	534,257	389	1,096	50	20,307	...	12	4	826	1,69,505 9 3
Differences	+ 1,481	+ 804	+ 635	+ 1,028	+ 1,255	+ 138	+ 19,033	+ 45,120	— 28,028	+ 17,092	+ 3,272	— 115,598	+ 39,628	— 210	+ 1,727	+ 6	+ 10,282	+ 6	+ 5	+ 8	+ 2,606	+ 30,869 3 3

474. The principal feature of the work of the year is the very large increase in the number of departmental maps and plans, &c., in hand and printed off; the number of subjects being 252 and of printed pulls 44,654 more than last year. This has thrown heavy work upon the Photographic and Zinc-printing sections. The extra-departmental work has also increased, especially in colour printing, the number of coloured copies issued being 22,300 more than last year, though the actual printed out-turn has been somewhat less. For colour printing, the steam machinery is a very great help, and we are able to meet demands for colour printing that could not possibly have been complied with without it.

475. The number of cadastral maps reproduced shows an increase of 961

sheets and of 4,917 pulls over last year. Of the North-West Provinces surveys, 3,409 sheets; of Burma 1,018 sheets; and of Assam 121 sheets were reproduced by photozincography or zincographed from tracings.

476. In the Type-printing section there has been a very large increase of 3,272 in the number of items set up, the number this year being 9,918 against 6,646 of last year. The number of pulls shows a falling off of 115,598 though the copies show an increase of 39,628.

477. Among the departmental maps the following may be noticed:—

The preparation of a third edition of the map of India on the scale of 1 inch= 32 miles, noticed in last year's report, has progressed, and corrections and additions have been made to sheets 1, 3, 4 and 5. There still remains much to be done in the eastern extension of sheet 4 and western extension of sheet 1, as new material comes in. The second edition of the plan of the City of Calcutta, lithographed on the scale of 6 inches = 1 mile, was completed but not printed off. This map will supply a great want pending the issue of a map based on the new survey of the city, which is likely to be delayed for some time to come, in consequence of unsettled boundaries. The 24-mile map of Afghanistan, photozincographed in two colours, has been completed and was awaiting final press order. The map of Burma and adjacent countries, in two sheets, on the scale of 1 inch= 32 miles, also photozincographed in two colours, has been printed off and published. A second edition of the Railway map of India, on the scale of 1 inch=32 miles, in six sheets, has been printed and issued: new editions of the skeleton Railway maps of India, on scales of 48 and 64 miles to the inch, were also photozincographed and issued. Editions of the same maps with the hills in grey were completed and awaiting press order.

The only new provincial map published has been one of Mysore State, in skeleton, on the scale of 1 inch=16 miles.

Among the district maps published is a preliminary edition of district Minbu, photozincographed on the scale of 1 inch=4 miles; also maps of districts Agra, Jaunpur, Bijnor and Ballia on the scale of 1 inch=2 miles, photozincographed for the North-West Provinces Government from drawings prepared in the Drawing-office, Calcutta. Seven of the series of District maps on the scale of 1 inch=4 miles, transferred from the engraved copper-plates, *viz.*:—districts Purneah, Bhagalpur, Darrang, Lakhimpur, Dacca, Chittagong and Singbhoom were transferred to stone, but not printed, and district Gya was printed off and published.

The number of standard sheets that have been actually in hand has been very large, amounting to 449, but of this number, only 124 have been published, among which are the following, *viz.*, 5 sheets of Bengal, on the 1-inch scale, in districts Cuttack and Mymensingh; 8 sheets of Bombay, on the 1-inch scale, in districts Belgaum, Dharwar, Jawhar States, Kolapur, Ratnagiri, Ramdurg and Sangli States and Thana; 10 sheets on the 4-inch scale in district Thana; 17 sheets of Lower Burma on the 4-inch scale in districts Henzada, Hanthawaddy, Prome, Tharrawaddy and Toungoo; 6 sheets on the 1-inch scale in districts Bassein, Hanthawaddy and Pegu: also 31 sheets of the North-West Provinces and Oudh, in districts Aligarh, Bahraich, Bara-Banki, Benares, Fyzabad, Gonda, Jaunpur, Kheri, Lalitpur, Mirzapur, Muttra, Partabgarh, Sultanpur and Sitapur, on the 1-inch scale; 14 sheets on the 2-inch scale, in districts Aligarh, Budaun and Etah; and 10 sheets of Madras surveys in districts Bangalore, Hassan, Kolar, Mysore and Tumkur of the Mysore State, on the 1-inch scale. Several of the maps of the reserved forests of the Madura district, on the 1-inch scale have been published, as well as 4 sheets of the South-East Frontier and 2 of the North-East Frontier on the $\frac{1}{4}$-inch and $\frac{1}{8}$-inch scales and 7 sheets of the Punjab, on the 1-inch scale, in districts Faridkot, Ferozepur, Hoshiarpur, Jullundar, Karnal, Kalsia, Ludhiana, Nabha, Patiala State, Sikh States and Umballa.

Among the miscellaneous items may be mentioned a panoramic profile of the Hill Ranges of the Himalayas seen from Landour, lithographed in colour from a drawing by Major St. G. C. Gore, R.E., which was printed off; also a soil map of the district of Gorakhpur, from an original prepared by Colonel Sandeman. Several technical charts and a large number of Index maps in colours have also been prepared and printed.

478. The extra-departmental work has been of its usual varied character. Among the principal items are a Forest map of India, in 4 sheets, on the scale

of 1 inch=48 miles, chromo-lithographed; a new Military map of India showing the military districts and commands in red, zincographed from transfers of the new edition of the 32-mile map of India; eleven route maps of Communications in military districts, lithographed from originals supplied by the military authorities, drawn but not printed; and ten more of the military maps of country, 10 miles round cantonments, lithographed and printed, *viz.*:—Gurgaon, Meerut, Agar, Rawal-Pindi, Dera-Ismail Khan, Murree Hills, Kohat, Jhelûm, Sialkot and Quetta.

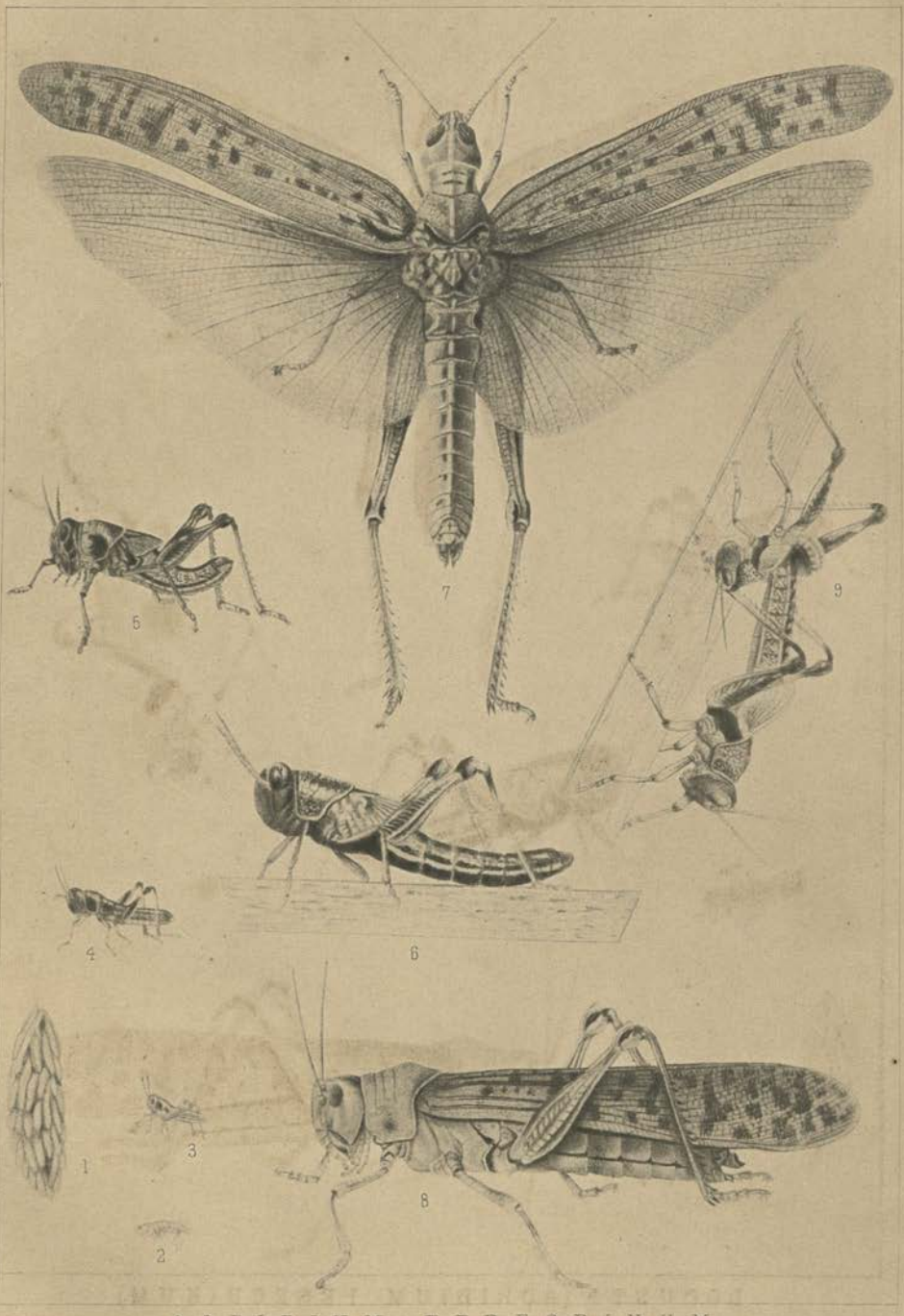
The Military and Railway map, chromo-lithographed in 12 sheets, on the scale of 1 inch=32 miles, regarding which the completion of the drawing was reported last year, has been abandoned for the original purpose for which it was prepared, but it has been decided to convert it into an ordinary departmental publication, and the necessary alterations for this purpose are now in hand. A larger number than ever of the coloured statistical maps for the illustration of the Administration Reports of the Government of Bengal, the Board of Revenue and other departments of the Bengal Government has been prepared and printed off from stone or zinc during the year, and for these, the application of steam power to the hand litho-machine was of immense assistance in getting the work through quickly and well. Thin zinc plates have also been very usefully employed in turning out this work. Ten similar maps of the Punjab, on the scale of 1 inch=80 miles, illustrating the Excise and Income Tax operations were prepared and printed in colours for the Punjab Government.

A large plan of the Port of Calcutta, in 10 double elephant sheets, has been photo-zincographed for the Port Commissioners. A great number of Weather charts and Meteorological diagrams have been printed for the Meteorological Department; also of plans, diagrams, &c., for other departments, as shown in the table in the appendix. The value of the extra-departmental work executed was R69,938-8-0, or ₹15,385-5-9 more than last year.

479. The Heliogravure section has been well employed during the year, and the out-turn shows a considerable increase both in plates and prints, as well as in electrotypes. By photo-etching, 56 plates have been produced with 30,589 prints; and 17 engraved plates have been electrotyped, either as matrices or duplicates. Among the subjects reproduced are 12 plates of the Technical Art Series of drawings of the Archæological surveys; some very delicate plates of pencil drawings of silkworm and other moths for the Indian Museum "Notes on Economic Entomology"; 6 plates for the Scientific Memoirs of the Medical Officers of the Army in India, among which are some very difficult subjects; also several plates for the Geological Survey Records, and the Journal of the Asiatic Society. A plate of a view of Kinchinjunga from Senchal, taken from a photograph by Messrs. Johnston and Hoffmann, was reproduced for the continuation volume of Markham's "Memoir on the Indian Surveys," now being prepared by Mr. C. E. Black of the India Office. The processes used are the same as in former years. The method has been applied as far as possible to maps and one plate of the Andaman survey on the scale of 1 inch=4 miles has been prepared, also two maps with brush-shading reproduced for the Quarter Master General's office, Intelligence Branch. Specimens of the present state of the process are given in the frontispiece, which represents a view of the Wanga Valley reproduced from a black and white oil monochrome drawing, on an orthochromatic plate in order to bring out the delicate bluish shades in the lights: and also in the plate given in the appendix which represents a street scene in Hyderabad, Deccan, from a negative by Surgeon-Major Newland.

480. Colonel Waterhouse reports the discovery of a new and simple method of producing reversed positives, direct in the camera, on ordinary gelatine dry plates with normal exposures, by the addition of minute quantities of various thio-carbamides, or sulpho-ureas, to the eikonogen developer. Though very complete reversals may be obtained, there is a difficulty in getting clear lights, but if this can be overcome the process will be very useful in the heliogravure work in many cases, by doing away with the necessity of producing a special transparency from the negative. Two plates of a line subject have been successfully engraved from positives produced in this way, and a specimen is appended which has been reproduced from a delicate shaded Indian-ink drawing. The value of the method will be seen by comparison with the same subject reproduced in the ordinary way.

BY THE ORDINARY PROCESS.

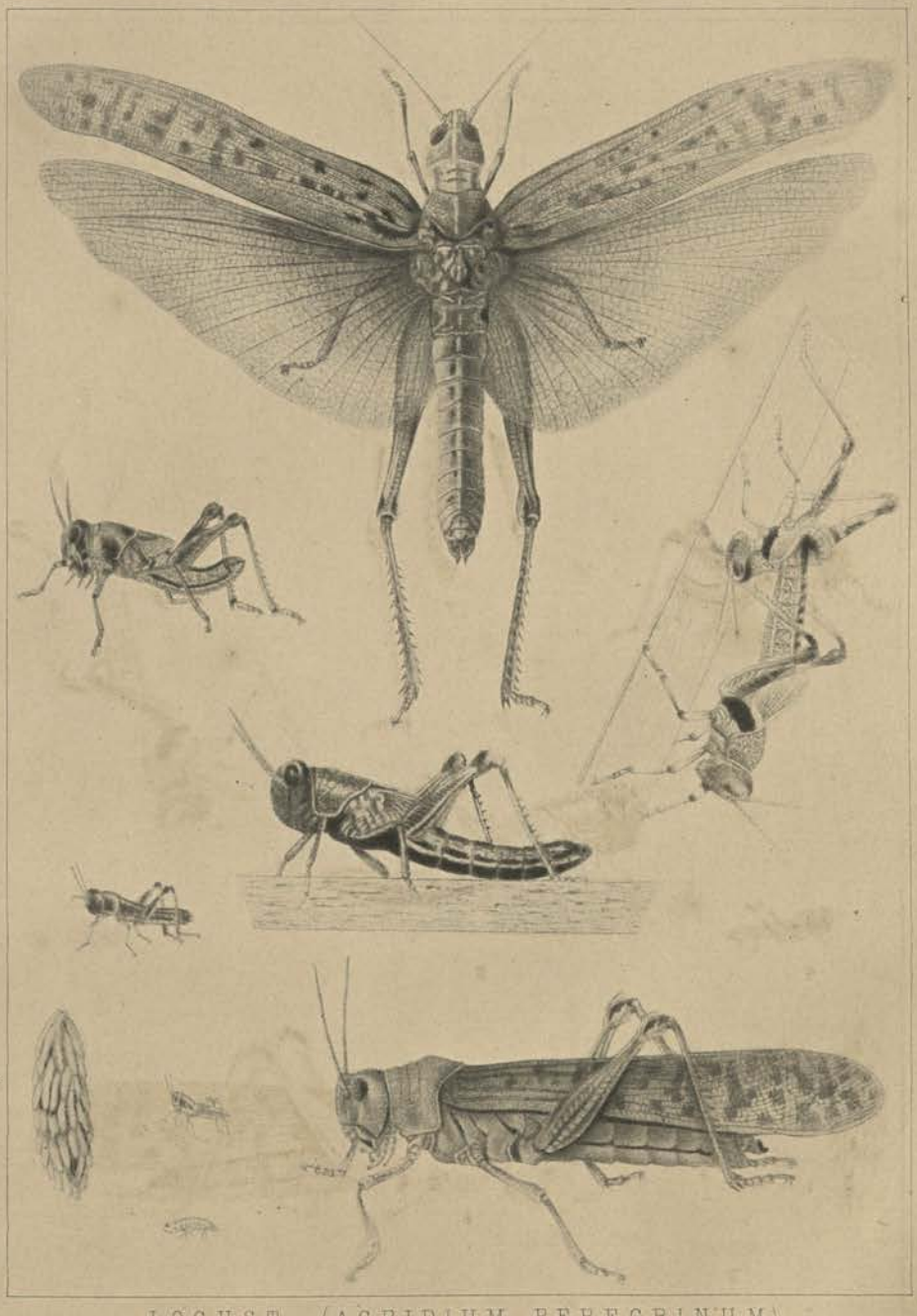


ACRIDIUM PEREGRINUM.

With its transformations.

1. Bundle of eggs.
2-6 Larvae in various stages of development.
7 & 8 Mature Locusts.
9. Larva Moulting its Skin.

Photo-etching from the original Drawing - Surveyed by [illegible] Office [illegible]



LOCUST (ACRIDIUM PEREGRINUM)

With its transformations.

Photo-etching from a direct transparent positive taken in the camera by Col. Waterhouse's reversal process with thio carbamides.

Survey of India Offices, Calcutta, February 1888.

Full accounts of this process and of other details connected with the working of the office are given in the appendix to Colonel Waterhouse's report.*

MAP RECORD AND ISSUE OFFICE.

481. Lieutenant-Colonel C. Strahan, R.E., held charge of this office at the commencement of the year, and was relieved by Major St. G. C. Gore, R.E., on the 25th October 1889, who held charge until the 22nd July 1890, when Mr. T. A. Pope was appointed to the charge and carried on the duties during the remainder of the year.

Personnel.

Lieutenant-Colonel C. Strahan, R.E., Assistant Surveyor-General, in charge to 25th October 1889.
Major St. G. C. Gore, R.E., Officiating Assistant Surveyor-General, in charge from 26th October 1889 to 22nd July 1890.
T. A. Pope, Esq., Officiating Deputy Superintendent, 4th grade, in charge from 22nd July 1890.
Mr. A. E. Byrn, Head Assistant.
„ H. R. Vallis, Map Curator, and 13 clerks.
„ B. M. Wilson, Assistant Surveyor, 2nd grade, attached.

482. During the year under report, the number and value of maps issued were as follows:—

Maps issued.	Number.	Value.
		₹
General Maps to Government officials	63,338	42,745
Ditto to India Office, London	19,41	2,838
Ditto to Agents	2,004	2,884
Ditto to private individuals on cash sale	8,500	10,809
Total	75,783	59,276
Cadastral Maps to Government officials	90,821	63,196
GRAND TOTAL	166,604	1,22,472

483. There has been a slight decrease in the number of maps issued, but an increase in their value, as compared with the previous year's totals.

484. During the past year, the actual cash sales amounted to ₹11,552, *viz.*, ₹10,808 realized from private individuals, and ₹743 from map sale agents. In the Revenue Section 737 applications were received for extracts from original records of the Revenue Surveys, and 3,344 certified copies of village plans, tracings, and traverses were supplied at a cost of ₹8,473.

485. The following statement gives the details of work done:—

Details.	Number.
Applications received for maps	4,598
Letter issued in reply	1,988
Cash and credit map Sale bills	1,444
Invoices and receipts issued for published maps	1,948
Ditto ditto for cadastral maps	224
Ditto ditto for extracts from original records	257
Packets, parcels, and local despatches	3,306
Ditto received in the office	668
Packages despatched by rail and steamer	442
Ditto received by ditto	39
Maps, coloured, for sale and issue	26,872
Ditto for other departments	1,800

* Colonel Waterhouse reports well of the conduct and satisfactory carrying on of their duties by his principal assistants, *viz.*—Mr. H. L. Lepage, Mr. S. Mackenzie, Mr. D. Deas, Mr. E. A. LeFranc, Corporal Vandyke and Mr. De Pyvah, in the Printing sections; Messrs. H. Haward, A. W. Turner, J. Harrold, R. George, in the Photographic sections. Among the assistants and apprentices may be mentioned Messrs. S. U. Ravenscroft, E. Dowling, J. T. Meade and C. J. Meade, G. Mackie, and P. Michael, who have all worked well and made good progress. Mr. J. T. Meade had charge of the Heliogravure section during Mr. Turner's absence on leave. The native clerks, draftsmen and assistants have generally performed their duties satisfactorily. Among them may be noted Babu Kanny Lall Sen, Head Clerk, whose duties have very much increased since the Photographic and Lithographic offices have been together; Babus Russick Lal Shaw and Gopal Chundra Mukerjee, clerks, Babus Umbica Churn Mukerji, Dinonath Das and Munshis Abdul Hamid, Abdul Mujid, Mahomed Yassin and Abdul Hakim, draftsmen; Mahomed Ismail, Habibul Hussan and Abdul Rahman, assistant photographers.

486. The rules regarding the issue of maps on the public service were revised during the year by the Government of India, who have laid down that all indents for printed maps required on service must be duly approved and countersigned by certain authorised officers before they can be complied with.

487. A list of maps published during the year is given at page 106.*

MATHEMATICAL INSTRUMENT OFFICE.

488. During the period under report, the charge of this office has been held by Lieutenant-Colonel M. W. Rogers, R. E., Assistant Surveyor-General, and during the absence of that officer on privilege leave from 21st July to the close of the year the charge was held by Major St. G. C. Gore, R.E., Officiating Assistant Surveyor-General.

Personnel.

Lieutenant-Colonel M. W. Rogers, R.E., Deputy Superintendent, 2nd grade, Assistant Surveyor-General, in charge up to 20th July 1890.
Major St. G. C. Gore, R.E., Officiating Assistant Surveyor-General, in charge from 21st July 1890.

Workshop Branch.

Mr. T. Bolton, Mathematical Instrument Maker, from 11th April 1890.
„ F. Marshall, Officiating Mathematical Instrument Maker, up to 10th April 1890, and Assistant Mathematical Instrument Maker from 11th April 1890.
„ T. R. Theakston, Assistant Mathematical Instrument Maker, up to 7th July 1890.
58 artificers on the Permanent Establishment.
112 „ on an average on the Temporary Establishment.
2 Eurasian apprentices up to August 1889.
1 „ apprentice.

Store Branch.

Mr. W. Campagnac, Instrument Storekeeper.
Babu Womesh Chunder Chowdhury, Material Storekeeper.
1 packing sirkar and 2 packers.

Office Establishment.

Mr. C. O. Gray, Head Clerk.
„ M. C. Belletty, 2nd Clerk.
6 permanent clerks, and 2 extra clerks.

489. The Patents Office of the Government of India was placed under the charge of the Assistant Surveyor-General from the 1st December 1889, and that officer was authorised to discharge all the functions of the Secretary under the Inventions and Designs Act V of 1888 from that date.

490. The figures given in this report refer to the financial year 1889-90, *i.e.*, from 1st April 1889 to 31st March 1890. During this period, 59,128 serviceable instruments, valued at ₹3,04,437 were received into store and 60,218 instruments, valued at ₹2,70,458, were issued; the number of instruments in store was therefore diminished by 1,090, whilst their value was increased by ₹33,979.

491. The following tabular statement shows the principal sources from which the serviceable instruments were received:—

Source of Receipt.	No.	Value.
		₹
From England on indent	8,014	1,42,815
By purchase in the local market	9,118	29,505
Manufactured in workshop	27,589	30,798
Returned to store by public officers	1,747	18,976
From other manufacturing offices	4,000	27
„ repairable stock after repair	7,969	78,414
„ other sources	691	3,902
TOTAL	59,128	3,04,437

492. The value of the instruments obtained from England is somewhat in excess of last year whilst the number of instruments has decreased, the average value of the instruments being larger.

* Of the Assistants in this office, Mr. H. R. Vallis is specially commended for the manner in which he has performed the somewhat arduous duties of Map Curator and Salesman.

The purchases in the local market are about the same as last year, whilst the number manufactured in the workshop is much larger in amount but smaller in value. This is due to departmental nomenclature, as pins for chains and maps are each classed as a separate instrument.

493. The number of instruments taken from the repairable stock and rendered serviceable for issue is very much larger this year than last, being more than double in number, and their value is greater by ₹25,000. As was explained in last year's report, this is hardly a fair comparison, as last year the workshop could not work up to its full powers; however, comparing this year's results with those of the year before last, 1887-88, there is an increase of about 2,000 instruments and ₹10,000 in value. During the year, the office received 10,961 repairable instruments (double the number received last year) valued at ₹69,127. The total issues from repairable stock were 8,340 valued at ₹66,342; of these, 7,809 instruments valued at ₹49,496 were repaired at a cost of ₹28,919 and transferred at the enhanced value to the serviceable stock. The repairable stock has thus been increased in value during the year by ₹2,785. This small amount of increase in the repairable stock is very satisfactory, as it indicates a cessation of the large increase of repairable instruments which at one time threatened to overwhelm the storing capabilities of the office, and to cope with which the two extra grants of ₹300 and ₹150 per mensem were sanctioned: it also indicates a saving in the indents and purchases of new instruments, as every repaired instrument rendered serviceable means one less required to be purchased new.

494. The conversion of old-fashioned and obsolete instruments, alluded to in paragraph 435 of last year's report, has been steadily proceeded with, and in the 15 months commencing from July 1889, 44 levels and 16 transit theodolites have been converted into serviceable instruments. The value of these instruments before conversion was nominally ₹5,965, but practically *nil*, whilst their issue value became ₹11,477.

495. During this financial year, 59,128 serviceable and 10,961 repairable instruments have been received into store, making a total of 70,089 instruments. The number of serviceable instruments has slightly decreased whilst their value has increased by about ₹34,000. The number of repairable instruments has increased, but the increase in their value is trifling.

496. During the year under report, 183 copies of the Indian standard yard were manufactured, compared and issued with the proper certificates to local Governments. All these copies were compared by the Assistant Surveyor-General in charge, and it entailed on him considerable extra labour.

497. The policy of enabling the Mathematical Instrument office to issue all its instruments duly verified and tested has been steadily carried out. An astronomical clock has been obtained and a transit instrument is expected from England and all the chronometers in store are duly rated and kept ready for issue. All hydrometers are also tested against the office standard before issue, and a new standard barometer with cathetometer and vacuum chamber has been obtained for comparing barometers in a similar manner to that in use at Kew.

498. The question of obtaining a supply of cheap instruments has occupied the attention of the officer in charge during the year. From correspondence with the Government of the Central Provinces, it became evident that the very high class of instruments which have as a rule been always supplied from the Mathematical Instrument office were not required, in many cases, for the use of native agency in the survey of that Province, and it was found that when simple instruments in any quantity were required they could be obtained direct from England at lower rates than from the Mathematical Instrument office. On this question being referred to the officer in charge of the Mathematical Instrument office, he pointed out that the Mathematical Instrument office rates were for superior instruments in small quantities, such as are generally indented for from the Mathematical Instrument office stores; but that if large orders were given and the quality reduced, the instruments could be supplied even more cheaply through the agency of the Mathematical Instrument office with the extra advantage of the inspection of each order before delivery. Accordingly, the Central Province authorities gave a large order for instruments which were all supplied at rates either the same as, or less than, those previously paid by the Central Provinces Government.

499. In connection with these requirements, it is a matter for consideration whether in the case of cheap simple instruments, the officer in charge of the Mathematical Instrument office might not be allowed to deal direct with the makers in England without the intervention of the India Stores Department, thereby avoiding the delay caused in India by drawing up and submitting indents, and also the delay in England owing to the procedure of the Stores Department in calling for tenders, &c. Governments and Departments in India generally give but short notice of their requirements and it is impossible to keep very large stocks in hand.

500. Table A (page lxxxii of the appendix) shows the amount of the debits against various Offices and Departments for instruments supplied and for work done. It also exhibits the credits for all instruments and materials returned to store. The value of the issues and repairs executed was R2,68,779 or nearly R60,000 in excess of last year and R36,000 in excess of the year before, with which it is more fairly comparable, as there were special causes diminishing last year's out-turn. This amount includes the value of instruments purchased by the extra-departmental grant of R30,000.

501. The credits for instruments returned into store amounted to R89,691 which is considerably more than last year. The cash sales were R10,203 against R9,807 in last year.

502. During the previous year, 9,612 instruments were purchased in the local market for R35,615; in the year under review the number was 9,118 and the value R29,505.

503. The actual number of instruments which have been manufactured in the workshop is more than double that of last year but their value is less by about R2,000. This is due to the large number of small, low-priced instruments which were required on indent. The figures for the last two years are given below:—

	No.	Value.
1888-89	11,220	33,082
1889-90	27,589	30,798

The class and value of these instruments will be found in Table C (page lxxxv of the appendix).

504. The number of principal instruments repaired in the workshop is 2,507, which is almost exactly the same as last year, the total number of instruments of all kinds repaired amounts to 3,104 compared with 3,186 in 1888-89.

505. The profit and loss account of the workshop will be found at page lxxxix of the appendix. The result of the operations therein is an apparent loss of R1,213 compared with an apparent loss of R2,926 on last year's work. The smallness of this amount shows that the charges made for repairs and manufactures have been very fairly correct, as of course it is the aim of the workshop to make such charges as will exactly balance the expenditure.

506. The whole experience of the last year has been to show that the demands on the Mathematical Instrument office for instruments and repairs are greatly increasing, as is only to be expected from the numerous Railway Surveys and other works of the kind which are everywhere in progress; and to supply these demands requires larger indents on England for instruments, extra money and increased workshop establishment. The Survey of India Department to which the Mathematical Instrument office is attached, although still its largest customer does not now take more than one-third of the total instruments issued.

507. Mr. Bolton, the Mathematical Instrument Maker, who had been on furlough in England for two years, returned and assumed charge of the workshops, &c., on the 11th April 1890, and Mr. Theakston who was brought out temporarily from England to render assistance during Mr. Bolton's absence, returned there on 8th of July on the termination of his engagement.

508. Stock-taking has been carried out continuously throughout the year whenever one of the Mathematical Instrument Makers could be spared for the purpose*.

* Colonel Rogers reports most favourably on the zeal and ability with which Messrs. Bolton and Marshall have carried out the work during the past year. The latter officer was in charge for two years during Mr. Bolton's absence on furlough, and carried out his duties in the most satisfactory manner. Mr. Theakston also worked well during the whole of his service. The Correspondence and Store Branches under Messrs. Gray and Campagnac have done their work most satisfactorily, and these gentlemen report well of all their subordinates.

II.—TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

509. The office embraces the following sections :—

(1) Correspondence, Accounts, and Records.
(2) Computing.
(3) Type-printing.
(4) Drawing and Compiling.
(5) Photozincography.
(6) Solar Photography.
(7) Miscellaneous, Meteorology, Store-godown, &c.

510. The principal work of this office, as a whole, is the final reduction and publication of the operations of the Trigonometrical branch of the Survey Department, in the furtherance of which, each of the first five sections mentioned above takes a share. These operations include the principal triangulation of the whole of India and the secondary triangulation executed in connection therewith; astronomical determinations of azimuth and of latitude; electro-telegraphic determinations of differences of longitude, and spirit-levelling operations, etc. Advantage is also taken of the facilities afforded by the office for calculating observations for latitude, azimuth, height, etc., taken by explorers; and, of late years, a good deal of work has been done in this respect, not only in connection with explorations carried out by the department itself, but also for officers of other departments.

Personnel.

Colonel G. Strahan, R.E., Deputy Surveyor-General, in charge Trigonometrical Branch.
Major St. G. C. Gore, R.E., Deputy Superintendent, 3rd grade, from 1st to 15th October 1889.
Mr. J. Eccles, M.A., Deputy Superintendent, 4th grade, from 8th September 1890.
Mr. E. C. Ryall, Assistant Superintendent, 1st grade, to 25th September 1890.
Lieutenant C. F. Close, R.E., Assistant Superintendent, 2nd grade, from 1st August to 7th September 1890.
Mr. W. H. Cole, M.A., Deputy Superintendent, 2nd grade, in charge Computing Party.

(1) Correspondence, Accounts, and Records.

Mr. F. A. D'Rozario, Head Clerk, and four writers.

(2) Computing.

Mr. C. Wood, Surveyor, 1st grade, to 3rd December 1889.
Mr. H. W. Peychers, Surveyor, 2nd grade.
Mr. L. J. Pocock, Surveyor, 3rd grade.
Mr. H. G. Shaw, Assistant Surveyor, 3rd grade, from 1st July 1890.
Babu Cally Mohan Ghose, chief computer.
Babu Kally Coomar Chatterjee, computer.
Babu Amba Prasad, computer, and 27 other permanent and temporary computers, Records and Account-Keeper and Librarian.

(3) Type Printing.

Mr. B. V. Hughes, Printer. Eighteen compositors and temporary hands.

(4) Drawing and Compiling.

Mr. G. W. E. Atkinson, Surveyor, 1st grade, to 31st January 1890.
Mr. N. C. Gwynne, Surveyor, 3rd grade, to 31st January 1890.
Mr. C. H. McA'Fee, Surveyor, 3rd grade.
Mr. W. J. Cornelius, Surveyor, 4th grade, to 31st January 1890.
Mr. A. Kitchen, Assistant Surveyor, 1st grade, to 31st January 1890.
Mr. H. Sindon, and 2 other draftsmen and 8 assistant draftsmen, to 31st January 1890.
Four draftsmen and 13 assistant and apprentice draftsmen.

(5) Photozincography.

Mr. C. G. Ollenbach, Zincographer, to 31st December 1889.
Mr. J. S. Manuel, Assistant Zincographer. Two photographers, 2 Native draftsmen, and 1 map-keeper.

(6) Solar Photography.

Mr. C. F. Guthrie, Assistant Solar Photographer.

511. The drawing and compiling section and the photozincographic section, although existing primarily as auxiliaries to the computing section, for the publication of maps, charts, etc., required to illustrate the survey operations, have also in course of time been taken advantage of for other work, such as the compilation and publication of exploration maps, charts of levels determined by railway and canal officers, and reduced to the Great Trigonometrical Survey datum of mean sea-level, and, latterly, the compilation and printing of trans-frontier maps. Under the orders of Government the compilation and drawing of the maps of the North-West trans-frontier was transferred to Simla, and a portion of the drawing section was transferred at the same time to form what is now known as the Simla Drawing office; while the space rendered available in the office has been filled by engaging ten temporary computers to aid in expediting the work still remaining to be done. The photozincographic section has further been made great use of by the Forest Department and the Quarter-Master General's Department.

512. The 6th section, *viz.*, solar photography, was instituted in 1877, in compliance with the request of the Industry, Science and Art Department, South Kensington, conveyed through the Home Government, that solar photographs might be taken to supplement those obtained at Kew. At first the size of the

photographs was only of 4-inch diameter, but subsequently a new enlarging lens was sent out, which increased the size to 8 inches, and later on a second large photo-heliograph was received, which gives pictures of the sun 12 inches in diameter. This latter, owing to the cost of the glass and chemicals for working it, is only used when special features are present on the sun's surface.

513. The 7th section deals with the depôt of instruments and stores attached to it, appertaining to the Great Trigonometrical Survey, of which it has for many years been the head-quarters, and also of a special instrumental equipment which has now to be maintained on a large scale. It includes the training of trans-frontier explorers, the instruction of departmental and other officers in taking astronomical observations, and in the use of instruments of the higher class. Scientific investigations in connection with the work of the Trigonometrical branch are also made from time to time. It deals also with some special meteorological observations.

514. During the past year the office has been actively engaged, as usual, in passing through the press the volumes of the Account of the operations of the Great Trigonometrical Survey. Volume XI, on Astronomical Latitudes, which was in the press when last reported on, has been completed and issued to all the principal scientific societies of the world. Volumes XII and XIII, containing the reduction of the Principal Triangulation of the Southern Trigon, have been bound and will shortly be issued. Volume XIV, containing the South-West Quadrilateral, is nearly through the press, and it is anticipated that the volume will be in the hands of the binder by January next. This volume completes the series devoted to the final reduction of the principal triangulation of India west of meridian 92°. There are in progress a volume of Electro-telegraphic operations and a volume on the Tidal operations, which have been carried out by the Trigonometrical branch of the survey.

515. The synoptical volumes of the different chains of triangles, including secondary work, which are published for the use of local officials and detail surveyors, are being proceeded with. Those of the Southern Trigon are now occupying special attention; one has been printed, and another will shortly be ready for the press; the remainder are in an advanced state. As soon as some of the computers can be spared from this work, the secondary work of the South-West Quadrilateral will be proceeded with. The office has also been occupied with the publication of hand-books of the Trigonometrical and Topographical branches, and a spirit-levelling pamphlet, No. 5, of the Madras Presidency.

In addition to the regular work of the office, assistance has been afforded to the astronomical parties by the loan of two computers for five months, and one computer was occupied for a month and-a-half in bringing up certain work of the Tidal and Baluchistan parties.

516. In the drawing and compiling section, the energies of the staff for the first four months were chiefly employed, as during the previous year, in the preparation of new trans-frontier maps: for the remainder of the year, the reduced establishment has been principally engaged in the special work of the Trigonometrical branch, as will be found detailed in the appendix.

517. Photographs of the sun have been taken throughout the year on all days that the sun was visible, and the negatives have been sent to England to the Solar Physics Committee at South Kensington. These photographs serve to largely supplement those taken at Greenwich, and their results are included by the Astronomer Royal in the yearly volumes of Greenwich observations.

518. Meteorological observations have continued to be taken as heretofore, including the record of the deep sunk thermometers; the sunshine record has also been maintained. The preservation and issue of instruments have been supervised, as usual, and the special equipment referred to above, kept in an efficient state. Two officers of the Quarter Master General's Department were instructed in the taking of astronomical observations for purposes of exploration, and one departmental officer also received special instruction in the use of instruments appertaining to the scientific work of this branch.

Further details of the work done will be found at page xc of the appendix.*

* Mr. Cole reports favourably on most of his assistants, making special mention of Messrs. Wood, Peychers, McA'Fee, Manuel and Hughes, who stand at the head of their respective sections; also of Messrs. Pocock and Shaw. He also bears testimony to the good work of Babu Cally Mohun Ghose and the other computers, as well as of Babu Sham Lall Banerjee, draftsman.

The Officiating Deputy Surveyor-General reports very favourably on the services rendered by Mr. D'Rozario, the head clerk, and Babu Hira Sing, 2nd clerk of his office.

III.—DRAWING OFFICE, SIMLA.

519. Under orders of the Government of India, Revenue and Agricultural Department, the main portion of the drawing and compiling section of the Trigonometrical Branch office, Dehra Dun, was removed from the administrative superintendence of the Deputy Surveyor-General, Trigonometrical Branch, from the 1st February 1890, and was placed under the immediate supervision of the officer in charge of the Baluchistan party, with a view to its transfer to Simla, in order that it might be associated with the Quarter Master General's Department for the purpose of preparing maps of the north-west trans-frontier, but to remain under the control of the Surveyor-General.

Personnel.

Lieutenant-Colonel T. H. Holdich, R.E., Deputy Superintendent, 2nd grade, in charge.
Mr. G. W. E. Atkinson, Surveyor, 1st grade.
„ W. J. Cornelius, Surveyor, 4th grade.
„ A. Kitchen, Assistant Surveyor, 1st grade, up to 29th May 1890, and from 7th July 1890.
„ F. E. Warde, Assistant Surveyor, 2nd grade, from 8th May 1890.
„ F. Rozario, Sub-surveyor.
„ H. Sindon, Draftsman.
Munshi Jafir Khan, Draftsman.
Mr. W. Manly, Assistant Draftsman, and four other draftsmen.

520. A good deal of time was taken up during the month of March, while at Dehra, in the separation of the various confidential and other records that were required at Simla or Calcutta, and great care had to be exercised in their selection, in order to avoid an unnecessary accumulation of records.

521. By the middle of April work was resumed in the office at Simla, which is located in the uppermost storey of the higher of the two secretariat blocks of buildings. Four rooms and a glazed verandah comprise the accommodation allotted for the office, which, though ample in space, is unfortunately not the best adapted for drawing purposes; the verandah only being sufficiently well lighted.

522. The establishment has been chiefly employed in the preparation of the western sheets of the north-west trans-frontier series and the maps of the south-west Asia series, on the scale of 1 inch = 8 miles; considerable labour and pains having been taken to extract all available information from the several gazetteers dealing with the tracts of country included within the areas covered by the several sheets, so as to render the maps as complete and accurate as possible. Good progress has been made in the preparation of the sheets of both series, and the method of printing in two colours, which has been adopted for both, may be regarded as an unqualified success.

523. Much of the work of this office consists in collating and comparing a vast mass of miscellaneous and other information, all bearing more or less on the geography of the lesser known parts of south-west Asia. Careful compiling and correct judgment in weighing conflicting evidence is very important and it demands a high class of intelligence.

524. Since the separation of this office from the Trigonometrical Branch office, eight sheets of the north-west trans-frontier and south-west Asia series on the $\frac{1}{8}$-inch scale have been sent to press, of which five have already been published. At the close of the year there were eleven sheets in the hands of the compilers and draftsmen, besides the two southern sheets of a new edition of the Turkestan map, and it is hoped that the office will shortly be in a position to take up a $\frac{1}{16}$-inch map of Baluchistan, which is urgently required.*

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* Regarding his assistants, Colonel Holdich reports as follows:—

"Mr. Atkinson, as Senior Assistant, has contributed much towards bringing the office up to its present level of orderly and efficient work. His duties have been varied, and he has at times been responsible for the conduct of the whole office during my absence. Under all circumstances, he has carried out his duties with much discretion and entirely to my satisfaction.

"Mr. Cornelius deserves recognition for his patient and painstaking compiling, and too much credit can hardly be given to him for his general success in this special branch of work.

"Mr. Kitchen's services have always been satisfactory, and Mr. Rozario, Sub-Surveyor, together with the draftsmen Messrs. Sindon and Manly and Jafir Khan, have all well maintained their reputation as sound workmen."

LIST OF MAPS AND CHARTS PUBLISHED DURING THE YEAR 1889-90.

Title.	Scale.	Number of Sheets.	Remarks.
Atlas of India.	In. M.		
Quarter sheets Nos. 11 S. E., 15 N. W., and 50 S. E.	1=4	3	
Sheet No. 55	1=4	1	With additions to 1889.
General Maps.			
Burma and adjacent countries	1=32	2	
India	1=64	4	Engraved, with additions to railways to January 1890.
Provincial Maps.			
Mysore	1=16	1	Preliminary edition, with additions to railways and corrections to boundaries to February 1890.
Punjab	1=16	4	With additions to boundaries and railways to March 1890.
Upper Burma	1=16	1	Preliminary Map (5th edition).
Punjab	1=32	1	With additions and corrections to November 1889.
Punjab and surrounding countries	1=32	1	With additions and corrections to June 1890.
Divisional Maps.			
Patna (Bengal)	1=8	2	
Bhagalpur Do.	1=8	1	
Dacca Do.	1=8	1	
District Maps.			
Agra (N. W. P.)	1=2	3	
Jaunpur Do.	1=2	3	
Bijnor Do.	1=2	4	
Ballia Do.	1=2	2	
Hazaribagh (Bengal)	1=4	1	With additions and corrections to September 1888.
Minbu (Upper Burma)	1=4	1	Preliminary edition, 1888-89.
Gya (Bengal)	1=4	1	With additions and corrections to September 1889.
Standard Maps.			
Andaman Islands.			
Sheets Nos. 1, 2, 9 and 10 (in one)	1=4	1	
Assam.			
Sheet No. 39	1=1	1	Preliminary edition.
Sheets Nos. 104, 105, 120 and 121 (in one)	1=2	1	2nd edition.
Bengal.			
Sheets Nos. 194, 195, 344, 346 and 362	1=1	5	
Bombay.			
Sheet No. 123	1=1	1	2nd edition.
Sheets Nos. 160, 205, 305, 306, 307, 332 and 333	1=1	7	
Sheet No. 216, N. E.	2=1	1	
Sheets Nos. 160 $\frac{\text{N. E.}}{3}$, $\frac{\text{N. W.}}{1}$, $\frac{\text{N. W.}}{3}$, $\frac{\text{S. E.}}{1}$, $\frac{\text{S. E.}}{3}$, $\frac{\text{S. E.}}{4}$, $\frac{\text{S. W.}}{1}$, $\frac{\text{S. W.}}{2}$, $\frac{\text{S. W.}}{3}$ and $\frac{\text{S. W.}}{4}$	4=1	10	Preliminary editions.

Title.	Scale.	Number of Sheets.	Remarks.
Standard Maps—*contd.*			
Burma (Lower).	In. M.		
Sheets Nos. 142, 187, 234, 281, 326 and 329	1=1	6	
Sheets Nos. 179 N. E. 3; 180 N. E. 2; 225 S. E. 3, S. W. 1, S. W. 2, S. W. 3, S. W. 4; 226 N. E. 1, N. E. 3, S. E. 1, S. E. 2, S. E. 3, S. W. 2, S. W. 4 and 227 N. E. 2	4=1	15	
Sheets Nos. 226 S. E. 4; and 227 S. E. 2	4=1	2	2nd edition.
Central India and Rajputana.			
Sheets Nos. 77, 178, 179, 180 and 251	1=1	5	
Central Provinces.			
Sheets Nos. 17 S. E. 2, S. E. 3, S. E. 4; 18 N. E. 1, N. E. 2, N. E. 3, N. E. 4, N. W. 4, S. E. 1, S. E. 2, S. E. 3, S. E. 4, S. W. 2, S. W. 4; 19 N. E. 2, N. W. 1, N. W. 2, N. W. 3; 25 S. W. 1 and S. W. 3	4=1	20	
Madras.			
Sheets Nos. 75, 80, 81, 111, 137, 141, 168, 169, 170 and 172	1=1	10	
North-West Provinces and Oudh.			
Sheets Nos. 23, 36, 39a, 52, 53, 57, 58, 59, 60, 79, 98, 131, 148, 149, 151, 152, 162, 169, 174, 175, 182, 184, 185, 192, 198, 200, 207, 208 and 212	1=1	29	
Sheet No. 180	1=1	1	2nd edition.
Sheets Nos. 23 N. E., S. E., 36 N. E., S. E., N. W., S. W., 37 N. W., 52 N. E., S. E., N. W., S. W., 53 N. E., S. E., and 185 N. E.	2=1	14	
Punjab.			
Sheets Nos. 225, 226, 253, 293 and 294	1=1	5	
Sheets Nos. 249 and 315	1=1	2	
Sheets Nos. 161 N. E. 4, S. E. 1; 184 N. W. 1, N. W. 3 & 4, S. W. 1 & 2, S. W. 3 & 4; 185 N. W. 1 & 2, N. W. 3 and S. W. 1	4=1	9	
North-Eastern Frontier Series.			
Sheet No. 14	1=8	1	
Sheet No. 14 S. E.	1=4	1	
South-Eastern Frontier Series.			
Sheet No. 1	1=8	1	Preliminary edition.
Sheet No. 1	1=8	1	2nd edition.
Sheet No. 3	1=8	1	
Sheet No. 1 N.E.	1=4	1	3rd edition.
Sheet No. 2 N.E.	1=4	1	4th edition.
Sheet No. 2 N.E.	1=4	1	5th edition
Plans of Cities and Cantonments.			
City, Cantonments and Environs of Benares	6=1	4	
City, Cantonments and Environs of Benares	8=1	4	
Index Maps.			
Index Chart of Triangulation of the Great Trigonometrical Survey of India	1=96	1	Corrected to 31st October 1889.

Title.	Scale.	Number of Sheets.	Remarks.
Statistical Maps.	In. -M.		
Railway Map of India	1=32	6	Corrected to January 1890.
Telegraphic Map of India	1=32	6	
Railway Map of India (with hills)	1=38	4	
Do. Do. Do.	1=64	2	
India shewing Railways	1=96	1	Corrected to 31st March 1890.
India illustrating the systems of Railways	1=96	1	Corrected to 30th June 1890.
Do. Do.	1=96	1	Corrected to 31st March 1889.
Miscellaneous.			
Reconnaissance of Road between Fort Lungleh and Fort Haka, 1889-90	1=2	1	
Reconnaissance of country traversed by the Northern Column, Chin-Lushai Expedition 1889-90	1=4	1	
Preliminary Sketch Map of Chin-Lushai Expedition, Chittagong Column, 1889-90	1=4	1	
Parts of Lushai, Cachar, and Manipur	1=8	1	
Pillaiyarnatham Reserved Forests, Melur taluk, Madura district, Madras	4=1	1	
Mudimalai Reserved Forest, Dindigul and Melur taluks, Madura district, Madras	4=1	1	
Alagar Hill Reserved Forest, Madura and Melur taluks, Madura district, Madras	4=1	2	
Vekkiramangalam Reserved Forest, Tirumangalam taluk, Madura district, Madras	4=1	1	
Portion of the Daling Hills, sheets Nos. 1 to 7	8=1	7	
Panoramic Profile of the Hill Ranges seen from Landour at (No. 1 H. S.) 7,533 feet above sea-level	...	1	
Triangulation Charts, &c.			
Gujarat Survey Triangulation, 1888-89	1=2	1	
Nos. 61, 62, and 63 of the Burma coast (Preliminary), between Cape Negrais and Sandoway, shewing the positions of Beacons and other points fixed, 1888-89	1=2	3	
Levels in the Punjab, sheet No. 66	1=2	1	2nd edition.
Secondary Triangulation in district Akyab (Northern half) 1856-61	1=4	1	
Secondary Triangulation in district Akyab (Southern half) 1856-61	1=4	1	
Triangulation of Country adjoining the Chittagong Hill Tracts, Lushai Expedition, 1889	1=4	1	

APPENDIX.

EXTRACTS

FROM

REPORTS BY EXECUTIVE OFFICERS.

UPPER BURMA TRIANGULATION.

Extract from the Narrative Report of MR. J. ECCLES, M.A., *in charge No. 24 Party—Season 1889-90.*

The country over which the triangulation was carried is very thickly wooded, the trees being very fine, and the undergrowth, for the most part bamboos, very thick. The eastern flank of the series is placed on high hills and offers no difficulties except those of approach; but the western flank from Omáza as far as Yamethin will necessarily rest on low undulating ground, and a great deal of line-clearing will be necessary for some time to come. The health of the party was extremely good all the season, and the signallers performed their duties very satisfactorily.

The instrument with which the triangulation was carried out is the new 12-inch theodolite numbered A-1888 or No. 1, by Troughton and Simms. It has two microscopes 180° apart, and is furnished with micrometer eye-pieces on the horizontal circle as well as a third index microscope, a similar system being also attached to the vertical circle. The telescope has also a micrometer eye-piece. Both horizontal and vertical circles have friction clamps, so that the zeros of the circles may be changed quickly at will. The performance of the instrument on the whole was good: at first it gave me some trouble, but this was the result, I think, of my own inexperience and of the unsteadiness of the signals due to atmospheric causes, rather than of the instrumental defects. The only real defect I found in the instrument was, that the horizontal clamp sometimes got loosened by the motion of the alidade, and this has since been remedied.

The method of observing was similar to that usually employed, except that the intersection was made with the micrometer wire: three sweeps, each on face right (R) and face left (L), were taken on each zero, provided no two angles on either of the faces differed by 2″, and the angles were measured on six pairs of zeros. As, however, the theodolite has only two microscopes, a pair of zeros gives no new graduations on the limb, and therefore the weights of the angles have been found by combining face R and face L together in one zero. In future, I think it would be better, and Colonel Rogers agrees with me, to take two sweeps on face R and two on face L, provided none of the four angles differ by 3″, and combine these four angles into one zero, measuring the angle on ten zeros. In taking the vertical angles the position of the zero of the vertical circle was never intentionally changed, as the error of intersection of a signal at the time of minimum refraction is probably much larger than that of the graduation of the vertical limb.

The triangulation was carried northward a distance of about 50 miles on each flank, observations being taken at eight stations and circumpolar azimuths at two of them. Owing to the method adopted in taking out the weights of the angles, *viz.*, by combining the right and left faces and so having only six zeros, the weights are comparatively small: their mean is 6·5, the highest being 20·5 and the lowest 1·3.

The triangulation has been adjusted in two figures, the first a five-sided figure, joined up by four diagonals, and the second a tetragon with a central station. The angles of the

latter figure are still subject to small corrections, as one of the central angles was not observed. This omission will be rectified at the beginning of the coming season.

The triangular errors come out fairly well: their mean is 0·82″, the largest being 1·51″ and the smallest 0·08″. The following is a comparison of the triangular errors between this instrument and the 36-inch and Waugh's 24-inch No. 1 :—

		Triangular error.
		″
36-inch in India	(hills)	0·41
24 „ „ „	„	0·39
24 „ „ „	(plains)	0·45
24 „ „ Burma	(combined)	0·73
12 „ „ „	„	0·82

The azimuthal observations were taken at Mya-ya-beng-kyo and Toungoo, the first to 51 Cephei and 8 Ursæ Minoris, and the second to Polaris and 1672 Bradley. The following are the results :—

Station.	Eastern Elongation.			Western.	Astronl. Mean.	Geodetic.	Astro.—Geod.
	°	′	″	″	″	″	″
Mya-ya-beng-kyo .	169	33	43·283	41·011	42·147	47·600	−5·453
Toungoo .	30	40	35·871	37·135	36·503	45·808	−9·305

The vertical observations gave nothing curious in their results: the refractions ranged from 0·060 to 0·072, with the exception of one short ray between Toungoo and Omáza over low, thickly wooded ground and intervening water; the co-efficient of refraction for this ray was 0·018.

Since returning from the field, some experiments have been made to determine the graduation error of the horizontal circle of the instrument. Two fine marks were made on a wall, and the instrument set up at the same distance, about 50 feet, from each, so that the focus had not to be altered. The angle between these marks was measured on 18 zeros 10° apart, two sweeps being taken on face R and two on face L, and the results treated much in the way described in the Account of the operations of the Great Trigonometrical Survey of India, Appendix 4 to Volume II.

The weight of the angle was found to be 14·18. The two microscopes on the horizontal circle should be 180° apart, and the result of the observations by two sets differing by 0·04″ from the mean, was that the angle between them is 180° 0′ 20·17″.

The periodic errors at any division Z is given by the expression—

$5{\cdot}93''\sin(Z-27°28') + 1{\cdot}47''\sin(2Z+114°9') + 2{\cdot}45''\sin(3Z+118°2') + 0{\cdot}42''\sin(4Z+160°56') + 0{\cdot}81''\sin(5Z+146°6') + \&c.$

These observations were further used to determine the relative values of the weight of the angle deduced from different numbers of zeros. The weight was found first from nine zeros with four sweeps on each zero, two on each face, and secondly from 18 zeros with two sweeps on each zero, one on each face. The result was that the angle came out the same in both cases, while the latter method gave a weight nearly double the former, justifying the proposal to increase the number of zeros from 6 to 9 and decrease the number of sweeps in each from 6 to 4. The conclusion which must be arrived at from these experiments, as well as from the season's work, is that the instrument is capable of giving observations comparable with those obtained by the larger class of instruments.

The following statement gives the details of the out-turn executed during the year :—

Description of details.	
Number of principal stations newly fixed	6
„ „ „ triangles completed	9
Length of principal series in miles	50
Area of principal triangulation in square miles	1,205
Average triangular error in seconds	0″.82
„ probable error of angles in seconds	0″.39
Astronomical azimuths of verification	2
Number of principal stations selected in advance	2
„ „ platforms constructed for principal stations	6
„ „ principal stations placed under official protection and protected	7
„ „ principal stations the elements of which have been computed	6
Area embraced by the triangulation to prominent points exterior to principal triangulation, in square miles	12
Number of points fixed by intersection but not visited	2
„ „ stations of points the heights of which have been determined	8
„ „ miles of rays and pathways cleared	30
„ „ preliminary charts of triangulation	1
„ „ hill-tops cleared of forest or jungle	6

CHITTAGONG AND BURMA COAST.

Extract from the Narrative Report of MR. T. H. RENDELL, *Surveyor, No. 24 Party—Season 1889-90.*

My instructions were to fix points along the coast at intervals of about 10 miles, suitable for marine survey purposes, preference being given to natural land-marks, such as hill peaks, conspicuous temples, light-houses, etc., and when these could not be had, artificial structures were to be erected of a description to suit the locality.

The part of the coast to be thus operated on lay between Kutabdia light-house in the Chittagong district and Akyab, a town in the Arakan division of Lower Burma, covering a total distance of 160 linear miles.

I had hoped to utilize the secondary stations of the Eastern Frontier Series, but I was disappointed to find that with one or two exceptions they all had disappeared and no trace of them could be found. I was therefore obliged to depend almost entirely on the principal triangulation, although this necessitated a good amount of jungle-clearing and attendant expense.

On examining the first 30 miles of the coast I found that it was quite out of the question to run an unbroken chain of triangles along it, as the jungle was so dense, and the mangrove swamp extended so far inland, that to effect it would have entailed undue expense. I therefore decided to fix a few suitable beacons in this locality by means of direct rays from the principal stations of the Eastern Frontier Series.

At Cox's Bazar I was fortunate enough to discover a secondary station of that series called Tongbrunanga H. S. A conspicuous and substantial beacon was erected here, and as the country from this point southwards along the coast was favourable for fixing points by triangulation, I adopted this means of fixing several prominent hill-marks and other objects.

My work was thus brought down as far as Nitong H. S., a principal station of the Eastern Frontier Series, or about one-half the total distance to be covered. The coast from this point southwards is fringed with heavy casuarina jungle, and as the hills inland are densely wooded, to avoid delay and heavy expense, I ran a traverse along the coast from Nitong H. S. to Sampagoi H. S., a distance of 43 miles, fixing six beacons *en route*. Konkheongtong H. S. was joined on to about midway as a check. For this work two chains were used, one 66 feet long, the other 100 feet; and to guard against errors I found it absolutely necessary to compare them twice daily with a standard bar immediately before and after each day's work. Check azimuths were observed at several intermediate stations; the distances were recorded to the nearest decimal of a foot. The co-ordinates of the traverse were computed with azimuths to the nearest second, and the result showed a difference of only 2¼ feet in 24 miles, or an average error of 1·25 inches in a mile.

The remaining one-third portion of the coast was got over by running a series of triangles starting from Sampagoi H. S., and closing on the side Agandu H. S.—Fakirmura H. S. In this portion of the work a light-house and several prominent hill peaks and other natural land-marks were fixed; in addition two artificial beacons were erected, one at Basura village, the other at the mouth of the Mayu river. Savage Island light-house, situated at the mouth of the Akyab river, forms the southernmost point of my season's work.

To sum up: 35 beacons, including six artificial structures, have been fixed along the coast, or an average of one in about 5 miles; this, it is considered, will be ample for all marine survey requirements.

It may not be out of place to give a description of one of the artificial beacons: Sonadia beacon is in the shape of a tripod having a base of 7 feet at the bottom, and meeting above at a point 26 feet above the ground. The tripod clasps a pole, which projects 14 feet above the top of the tripod, and carries a cross-arm made of bamboo. The legs of the tripod are braced together, and together with the central pole are let into the ground to the depth of about 6 feet.

The season's work has been projected on three sheets, Nos. 56, 57, and 58, corresponding to the sheets of the Coast triangulation.

ELECTRO-TELEGRAPHIC LONGITUDE OPERATIONS.

Extract from the Narrative Report of CAPTAIN S. G. BURRARD, R.E., *in charge of No. 22 Party (Astronomical)—Season 1889-90.*

After the first three weeks, when Lieutenant Conyngham had become accustomed to working with a transit instrument and had assumed a fixed habit of observing, we measured our personal equation, taking thirty stars on three successive nights. By November 1st, Lieutenant Conyngham was sufficiently acquainted with the use of the transit instruments and the electrical apparatus to justify our commencing regular longitude work.

The arcs assigned for measurement during the season were as follows:—

1. Agra-Mooltan.
2. Agra-Kurrachee.
3. Agra-Kalianpur.
4. Kalianpur-Bombay.
5. Jubbulpore-Kalianpur.
6. Mooltan-Kurrachee.
7. Mooltan-Quetta.
8. Kurrachee-Quetta.

On November 1st, Lieutenant Conyngham left Dehra-Dun for Mooltan, and I started for Agra. We commenced the measurement of the Agra-Mooltan arc on November 15th: as it was the first arc of the season, we devoted eight full nights' work to it. On its completion Lieutenant Conyngham moved to Kurrachee and we took up the Agra-Kurrachee arc, the largest ever measured in India.

On December 17th we met at Agra and observed together a full programme of stars for personal equation on four successive nights. Lieutenant Conyngham then left for Kalianpur, and we proceeded to measure the Agra-Kalianpur arc, completing it on January 2nd, 1890. A special line wire had been constructed in October by the Government Telegraph Department from Basoda, a station of the Indian Midland Railway, to Kalianpur, a distance of 30 miles, to allow of the latter being connected with the Indian system of electro-telegraphic longitudes.

The next arcs taken up were those of Kalianpur-Bombay and Jubbulpore-Kalianpur, both of which were completed by February 9th, Lieutenant Conyngham remaining at Kalianpur throughout, whilst I moved from Agra to Bombay and thence to Jubbulpore. No. 22 Party then moved from Jubbulpore to Mooltan, and No. 23 from Kalianpur to Kurrachee, and on March 1st we were ready to begin work on the Mooltan-Kurrachee arc.

This arc, Mooltan-Kurrachee, had been previously measured, and it was believed to be largely in error. During the current field season from November 1889 to February 1890, I had been carrying out at Agra, Bombay, and Jubbulpore some experiments with my telescope and had obtained some peculiar and unexpected results (the experiments are described and the results given hereafter). It appeared from these results that another source of error existed in longitude work, of which we had been hitherto unaware, and that our determinations of collimation by Gauss's method were by no means as infallible as had been believed. To eliminate this new source of error, however, it seemed only necessary to compute the collimation constant by a different method to that hitherto employed; and on applying this new method to the work of the season 1885-86 (retaining the observations just as they were made and recorded, and merely computing the collimation constant differently), I found that the circuit errors, which had proved so abnormally large, almost vanished. The arc Mooltan-Kurrachee, in fact, now appeared entirely free from error and the necessity of revising it seemed more than questionable.

We were not in full possession of all these facts until we had actually begun the revision of the Mooltan-Kurrachee arc: if then the measurement had been run through in six nights, it might have been worth while carrying it out, but as we had already wasted ten days over it without securing any observations owing to clouds, I asked the Deputy Surveyor-General whether we should continue or abandon it: the two Quetta arcs that had yet to be observed were both likely to be delayed by clouds, and in order to secure their measurements the Deputy Surveyor-General directed me to give up the revision of Mooltan-Kurrachee.

Lieutenant Conyngham joined me at Mooltan on March 15th, and we measured our personal equation on the two following days. He then left for Quetta, and on the 23rd we began the Mooltan-Quetta arc. We were both much harassed by clouds, but completed the measurement on April 1st. I then moved to Kurrachee, and on April 7th we commenced the Kurrachee-Quetta arc, finishing it on April 13th. We completed the season's work by observing for personal equation at Kurrachee on April 16th and 17th.

Throughout the operations all the officers of the Telegraph Department, whose co-operation was in any way required, continually shewed me the greatest courtesy and willingness to render every assistance in their power. In many instances I fear the prosecution of longitude observations has unavoidably caused considerable trouble in the several telegraph offices involved, but this has invariably been undertaken with extreme readiness. I feel myself much indebted to the Chief Superintendents of the Nagpur, Ajmere, and Baluchistan divisions, and to Mr. Dowson, who was in charge of the great central office at Fobay. I also wish to express my obligations to Mr. Chambers, the Astronomer in charge of the Bombay observatory, for his kind assistance.

I now proceed to give the results of the season's work:—

RETARDATION.

Let us suppose on any arc measured, say, between stations E and W, the retardation of the current from E to W be ρ' and from W to E be ρ''; let the value of the arc of longitude, as found by observations with E clock, be denoted by the symbol ΔL_E, and when determined by observations with W clock ΔL_W: and let ΔL be the true difference of longitude required. If electricity acted instantaneously, ΔL would be equal both to ΔL_E and to ΔL_W and both ρ' and ρ'' would be equal to nothing. But as an electric signal takes a sensible time in passing from one station to the other, considerable differences are found to obtain in practice between the values of ΔL_E and ΔL_W. Now, on any arc, we know that $\Delta L = \Delta L_E + \rho'$, and again $\Delta L = \Delta L_W - \rho''$.

We have no means of determining ρ' and ρ'', and we consequently have to take $\Delta L = \frac{\Delta L_E + \Delta L_W}{2}$.

It is evident that theoretically $\Delta L = \frac{\Delta L_E + \rho'}{2} + \frac{\Delta L_W - \rho''}{2} = \frac{\Delta L_E + \Delta L_W}{2} + \frac{\rho' - \rho''}{2}$; we neglect the last term of the equation, *viz.*: $-\frac{\rho' - \rho''}{2}$, thereby assuming that $\frac{\rho' - \rho''}{2} = 0$, or $\rho' = \rho''$; (in other words, that the retardation of a current from E to W is the same as from W to E). Taking the above equations again $\Delta L = \Delta L_E + \rho'$ and $\Delta L = \Delta L_W - \rho''$, we get $\Delta L_E +$

$\rho' = \Delta L_W - \rho''$ or $\rho' + \rho'' = \Delta L_W - \Delta L_E$. ΔL_W and ΔL_E are known quantities given by observation, and we can therefore always find the sum of the two retardations $(\rho' + \rho'')$. In estimating approximately what error we incur by assuming $\rho' = \rho''$, our only data to go upon is the value of $(\rho' + \rho'')$. The value of $(\rho' + \rho'')$ is here given for the arcs of this season—

Arcs.	ΔL_E	ΔL_W	$\rho' + \rho''$	$\frac{\rho' + \rho''}{2}$ commonly spoken of in Vol. IX as the retardation.
	m s	m s	s	s
1. Agra-Mooltan	26 19·009	26 19·175	0·166	0·083
2. Agra-Kurrachee	44 0·859	44 1·125	0·266	0·133
3. Agra-Kalianpur	1 27·266	1 27·372	0·106	0·053
4. Kalianpur-Bombay	19 21·355	19 21·528	0·173	0·086
5. Jubbulpore-Kalianpur	9 10·275	9 10·371	0·096	0·048
6. Mooltan-Quetta	17 43·450	17 43·548	0·098	0·049
7. Kurrachee-Quetta	0 1·525	0 1·681	0·156	0·078

To try the effect on an arc of our assumption in the matter of retardation, take a supposititious case, and let $\rho' + \rho'' = 0^s{\cdot}20$: we assume that $\rho' = \rho'' = \frac{\rho' + \rho''}{2} = 0^s{\cdot}10$. It might conceivably happen that, under such circumstances, ρ' was equal to $0^s{\cdot}05$, and ρ'' to $0^s{\cdot}15$: the error in the value of the arc would then be $\frac{\rho'' - \rho'}{2} = \frac{{\cdot}15 - {\cdot}05}{2} = 0^s{\cdot}05$. This example is taken to shew that if $\rho' + \rho'' = {\cdot}20$, the value of ΔL may quite possibly be ·05 in error, or, in other words, that any arc of longitude may possibly be in error by an amount equal to one-quarter the sum of the two retardations (or to one-half the so-called mean retardation of Volumes IX and X of the Account of the Great Trigonometrical Survey).

Just before work on the first night of the Agra-Kurrachee arc, I was testing the electrical apparatus and was unable to pass a current through my receiving relay. A week before, I had been working with it on the Agra-Mooltan arc: it had then answered perfectly, and it had not been touched afterwards. The equalisation of the retardation in the two directions of an arc may be of importance, and my impression was that the relays in both the longitude equipments had been especially made of the same resistance under Colonel Campbell's directions, about 1874. I was therefore unwilling to introduce a new relay into the apparatus for fear of complicating the question of retardation, but was at last obliged to borrow one from the Assistant Superintendent of Telegraphs, as I could do nothing with my own.

On the Agra-Kurrachee arc the value of $(\rho' + \rho'')$ has been given at $0^s{\cdot}266$: in accordance with the system in vogue we have assumed the retardation from Agra to Kurrachee to be equal to that from Kurrachee to Agra, thus:—$\rho' = \rho'' = 0^s{\cdot}133$. The value of the arc has been given as follows:—

$$\Delta L = \frac{\Delta L_E + \Delta L_W}{2} = 44^m\ 0^s{\cdot}992.$$

The current from Kurrachee to Agra passes, through the receiving relay at Agra, which had just been replaced, but the return current from Agra to Kurrachee does not.

I think it quite possible, judging from the retardation on other arcs, that the retardation from Agra to Kurrachee was $\rho' = 0^s{\cdot}07$, and that therefore the retardation from Kurrachee to Agra was $\rho'' = 0^s{\cdot}266 - \rho' = 0^s{\cdot}196$. Then $\Delta L = \frac{\Delta L_E + \Delta L_W}{2} + \frac{\rho' - \rho''}{2} = 44^m\ 0^s{\cdot}992 + \frac{0^s{\cdot}07 - 0^s{\cdot}196}{2} = 44^m\ 0^s{\cdot}930$, shewing a possible error in the final value of the arc of $0^s{\cdot}062$.

The line wire from Agra to Kurrachee was exceptionally long; all our signals throughout were greatly interfered with by induced currents, and our relays were very difficult to adjust: but as far as I can see, there are no definite data to go upon, and so we must accept the value $44^m\ 0^s{\cdot}992$ for Agra-Kurrachee.

It is perhaps worthy of mention that in 1880-81 on the arcs Bombay-Kurrachee and Jubbulpore-Bolaram, the value of $(\rho' + \rho'')$ exceeded 0·20, whilst on Jubbulpore-Bombay it was as much as $0^s{\cdot}18$ (*vide* G. T. Survey, Volume IX).

I sent the old relay of the party to the Government workshops at Calcutta, where, on examination, one of the coils was found to have failed. The resistance of the coils, which should have been but three Ohms, on being tested was found to be something over a million.

In the longitude equipments there are no instruments, and never have been any for

determining the resistances of the several coils, and so the observers never know whether these resistances are varying or not.

It was not till December 1st that I first noticed something was wrong with my receiving relay, and then my attention was drawn to it from the simple fact that no current would pass at all. I had been working with this relay on the Agra-Mooltan arc from November 15th to 22nd: from November 22nd to December 1st, it had remained untouched under lock and key, in the clock room at Agra. If I had been moving by rail between November 22nd and December 1st, the sudden failure of the relay could have been accounted for as the result of a jar in transit. But the fact of its failure apparently without cause on December 1st shews, I fear, that it must have been out of order during the observations from November 15th to 22nd; its resistance had probably been increasing for some time, and was perhaps abnormally high on the Agra-Mooltan arc. During work on that arc I had no suspicion of anything being wrong, but this fact cannot count for anything, as the resistance of a relay cannot attract attention until it has risen so high that no current will pass at all. The resistance of my receiving relay was in 1875 but three Ohms: it may have remained at three Ohms until it suddenly failed last December, or it may, on the other hand, have been gradually increasing with age for some lengthened period.

At Bombay I had very great difficulty in receiving the Kalianpur signals: the Kalianpur battery, though it had proved sufficient on the short line from Agra *viâ* Gwalior and Jhansi to Kalianpur, was too weak to work my relay at Bombay *viâ* Bhusaval. My battery at Bombay, when working with Kalianpur, consisted of seventy bichromate cells, whereas the Kalianpur battery, working on the same length of line, was only thirty-three Menottis: as one bichromate cell is equal to two Menottis, my battery was some four-and-a-half times as strong as Lieutenant Conyngham's. When the Telegraph Department were constructing the line to Kalianpur, they had established a telegraph office at Sironj (a large Mohammedan town 2 miles from Kalianpur), and the Sironj battery consisted of twelve Menotti cells; by means of these, Lieutenant Conyngham was able to increase his battery strength to forty-five Menottis.

We were in some doubt as to whether it was theoretically correct to have batteries of such unequal strength at the two extremities of an arc; and as Lieutenant Conyngham could not raise his battery to the strength of mine, the question arose as to whether I should not decrease mine to the level of his. One certain effect of such a decrease would have been to give Lieutenant Conyngham the same difficulty in receiving my signals at Kalianpur, as I had in receiving his at Bombay. This difficulty is not merely a matter of trouble; with a weak battery the receiving relay has to be very finely adjusted, and the result is that it can be worked by induced currents: at Bombay the Kalianpur signals frequently ceased to arrive, and telegraphic messages that were being sent by neighbouring wires were recorded on my chronograph instead. The chronographic record is thus much interfered with and numerous stars are lost. We eventually decided that good signals at one end were better than bad at both, and so worked with unequal batteries. I had never read anything to lead me to suppose that the velocity of electricity is greater with a stronger battery, though presumably it is less with increased resistance. Moreover, in G. T. Survey, Vol. IX or X, there is no mention of the necessity of equalising the battery-power. Unfortunately the retardation on the arc Kalianpur-Bombay is largely in excess of what I had expected, and is about twice as large as it should have been. The sum of the retardations in both directions is 0·172; and though there is no direct evidence in the matter, it is quite possible that three-fourths (0·13) of this may be due to the direction from Kalianpur to Bombay, and one-fourth (0·04) to the direction from Bombay to Kalianpur.

There is another peculiarity worthy of attention in the preceding table of retardations: the western station of the two last arcs of that table was at Quetta: the line wire from Mooltan to Quetta crossed the Indus at Sukkur, where it joined the line wire from Kurrachee to Quetta, so that on both arcs the same line wire from Sukkur to Quetta was employed. The line wires joining Sukkur to Mooltan and Kurrachee respectively were as nearly as possible equal. The electrical apparatus, the batteries, and the cells of No. 23 Party remained undisturbed at Quetta throughout the observations on both arcs. The only change of conditions between the two arcs was that No. 22 Party moved from Mooltan to Kurrachee; and yet the value of $(\rho' + \rho'')$ on Mooltan-Quetta is 0·098, and on Kurrachee-Quetta 0·156—a very large difference that I am quite unable to account for.

If we are compelled, from want of an alternative method, to assume ρ' and ρ'' equal, some steps should at least be taken to render them equal in practice. It has been surmised that the retardation of a current varies with the resistance or some function of the resistance; and if both observers were supplied with the proper instruments, they could always maintain the resistance of their line-circuit at some fixed quantity.

Final results of the Season's work.

The values of the arcs measured during this season, 1889-90, are given here in tabular form: the geodetic values of the arcs are omitted, as I have been unable to obtain any reliable value for the geodetic longitude of Quetta—

Arcs.	Electro-Telegraphic longitude value.	
	m.	s.
1. Agra-Mooltan	26	19·092
2. Agra-Kurrachee	44	0·992
3. Agra-Kalianpur	1	27·319
4. Kalianpur-Bombay	19	21·441
5. Jubbulpore-Kalianpur	9	10·323
6. Mooltan-Quetta	17	43·499
7. Kurrachee-Quetta	0	1·603

It should be carefully noted that the above values of the arcs are those that result *if the new method of deducing the collimation constant be adopted*: these same arcs have also been computed on the old method, and their values by that method given hereafter.

To the seven arcs measured this season we can apply four tests of the correctness of their values as follows:—

	m.	s.
(1) Agra-Mooltan as observed in 1889-90	=26	19·092
Agra-Mooltan as observed in 1885-86	=26	19·013
Difference between the two measurements	= 0	0·079
(2) Agra-Mooltan as observed in 1889-90	=26	19·092
Mooltan-Kurrachee as observed in 1885-86	=17	41·975
Their sum gives the value of the arc Agra-Kurrachee	=44	1·067
Agra-Kurrachee as observed in 1889-90	=44	0·992
Closing error	= 0	0·075
(3) Mooltan-Kurrachee as observed in 1885-86	=17	41·975
Kurrachee-Quetta as observed in 1889-90	= 0	1·603
Their sum gives the value of the arc Mooltan-Quetta	=17	43·578
Mooltan-Quetta as observed in 1889-90	=17	43·499
Closing error	= 0	0·079

(4) We may omit Mooltan-Kurrachee altogether, and only include the four arcs of this season's operations in the circuit: in other words, we can determine the difference of longitude between Agra and Quetta in two ways, (i) *viâ* Mooltan, (ii) *viâ* Kurrachee, and compare the results:—

	m.	s.
Agra-Mooltan as observed this season	=26	19·092
Mooltan-Quetta	=17	43·499
Sum gives the difference of longitude between Agra and Quetta	=44	2·591
Agra-Kurrachee as observed this season	=44	0·992
Kurrachee-Quetta	= 0	1·603
Sum gives difference of longitude between Agra and Quetta	=44	2·595
Difference between the two results	= 0	0·004

The 1885-86 value of Agra-Mooltan is, I believe, the more trustworthy, and I recommend its adoption. The 1889-90 value might be objected to on the grounds that it was the first occasion on which Lieutenant Conyngham had observed, but this objection would not hold: the observations throughout the arc appear excellent, and it is quite impossible for an error of 0·02 (much less one of 0·079) in the final result to be due to bad observing. I think that the error in the 1889-90 value cannot be attributed to anything but retardation, and that it has been caused by the abnormal resistance of the old receiving relay at Agra.

If we employ the 1885-86 value of Agra-Mooltan in the second of the above tests, the closing error is reduced from 0·075 to 0·004. This test shews the Agra-Kurrachee arc to be free from any large error; for the two arcs of 1885-86, Agra-Mooltan and Mooltan-Kurrachee, are of a high order of merit: the new relay must, therefore, have exercised no bad effect, and the abnormal amount of retardation exhibited must have been due to bad insulation, extreme length of line, or induced currents, all of which would equally hold in both directions.

The correctness of the values of the three Kalianpur or Central Indian arcs of this season may be tested as follows:—

	m.	s.
(1) Jubbulpore-Agra as measured in 1880-81, and recomputed by the new method in 1889-90	= 7	43·021
Agra-Kalianpur as measured in 1889-90	= 1	27·319
Sum should give the value of the arc Jubbulpore-Kalianpur	= 9	10·340
Jubbulpore-Kalianpur as measured in 1889-90	= 9	10·323
Closing error	= 0	0·017
(2) Jubbulpore-Kalianpur as measured in 1889-90	= 9	10·323
Kalianpur-Bombay	= 19	21·441
Sum should give the value of the arc Jubbulpore-Bombay	= 28	31·764
Jubbulpore-Bombay as measured in 1880-81	= 28	31·816
Closing error	= 0	0·052
(3) We may determine the difference of longitude between Agra and Bombay as follows:—		
Agra-Deesa measured in 1880-81	= 23	20·375
Bombay-Deesa	= 2	31·643
Difference = Agra-Bombay	= 20	48·732
Bombay-Jubbulpore as measured in 1888-89	= 28	31·816
Jubbulpore-Agra	= 7	43·021
Agra-Bombay	= 20	48·795
Mean value as derived from the operations of 1880-81	= 20	48·764
Agra-Kalianpur as measured in 1889-90	= 1	27·319
Kalianpur-Bombay	= 19	21·441
Value of Agra-Bombay as derived from the operations of 1889-90	= 20	48·760
Difference between the 1880-81 and 1889-90 results	= 0	0·004

The results of these three tests are eminently satisfactory; there are good reasons for believing that the closing error of 0·052 in the second test is due, for the most part, to the old arc Jubbulpore-Bombay, and I think it improbable that any one of the three arcs ending at Kalianpur can be in error by 0·015.

The Longitude of Kalianpur.

Kalianpur is the origin of the Great Trigonometrical Survey of India, the pivot on which the whole triangulation has been hung: it is a small deserted village of no political importance, situated in the territories of the Nawab of Tonk, within 3 miles of the large city of Sironj. It lies near the centre of the Indian Continent at the junction of the two most important series of triangulation in India: the Great Arc which follows the meridian of 78° from Cape Comorin to the Himalayas and the Great Longitudinal Series that runs from Kurrachee to Calcutta: it was selected on account of its situation as the origin of the Indian Survey by Colonel Everest in 1840.

The longitude of Kalianpur has hitherto been taken as 77°-41′-44″·75, and all other longitudes in India have been calculated through the triangulation from this initial value.

No direct observations for longitude were ever taken at Kalianpur, and the value 77°-41′-44″·75 hitherto adopted was deduced indirectly from Madras.

The astronomical longitude of Madras was determined by means of moon culminations observed in the year 1815 at 81°-17′-21″·00: the amount that Kalianpur was west of Madras was computed through the old triangulation of Colonel Lambton and found to be 2°-35′-36″·25. The longitude of Kalianpur was thus derived by Everest as follows:—

	°	′	″
Longitude of Madras east of Greenwich by observations of moon culminations	= 80	17	21·00
Longitude of Kalianpur west of Madras deduced from triangulation	= 2	35	36·25
Longitude of Kalianpur east of Greenwich	= 77	41	44·75

In 1877 the longitude of Madras was re-determined by means of the electro-telegraph and found to be 80°-14′-50″·03 east of Greenwich, or 2′-30″·97 in defect of the former values.

The triangulation connecting Madras and Kalianpur was afterwards revised under Colonel Everest and General Walker, and the difference of longitude between the two was computed afresh and with a new result.

Everest's value of the longitude of Kalianpur was therefore known to be in error, firstly, by 2′-30″·97 owing to the original longitude of Madras having been shewn by

electro-telegraphic observations to be that amount too large, and secondly, by another smaller quantity owing to the difference of longitude between Madras and Kalianpur given by Lambton's triangulation having been shewn too large by the recent triangulation under General Walker.

The longitude of Kalianpur has now been determined directly by electro-telegraphic operations; its value east of Greenwich can be deduced as follows:—

	°	′	″
Difference of longitude between Greenwich and Makattam	31	16	33·60
" " " Makattam and Suez	1	16	43·95
" " " Suez and Aden	12	25	42·00
" " " Aden and Bombay	27	50	0·30
" " " Bombay and Kalianpur	4	50	21·61
Longitude of Kalianpur East of Greenwich	77	39	21·46

From this it appears that the value adopted by Colonel Everest and hitherto employed in the Great Trigonometrical Survey of India is 2′-23″·29 too large.

The new method of determining the Collimation Constant.

C_0 is the reading of the micrometer head when the line of collimation is perpendicular to the axis of rotation. We determine the value of C_0 from two horizontal collimators by Gauss's method. It has happened as often as not with both transit instruments of the Indian Survey that the value of C_0, when determined I. P. E., has differed by some appreciable quantity from its value when determined I. P. W.

The circuit errors that resulted from the operations of the season 1872-73 and 1881-82 had proved abnormally large: on each occasion a fault had been found in either one or both telescopes at the joint of the object end table with the cube of the transit axis: the joint had become infirm and shaky, and the line of collimation was consequently unsteady. In 1883-84 symptoms of the same weakness reappeared, and the telescopes had to be sent to England.

"*Unsteadiness of the line of collimation*" thus became a source of constant anxiety to observers, and of late years has gradually attained an undue prominence.

The possibility of the existence of other sources of error has, in fact, been lost sight of owing to our recent tendency to attribute every unexplained phenomenon to "unsteadiness of collimation."

In 1885-86 the circuit errors were again abnormally large, but throughout the season there had been no indication whatever of unsteadiness in C_0. The explanation, however, of their presence which found most most favour was, that the line of collimation *did* change when the telescope was being moved from the horizontal position to the zenith. The burden of the reports was: "During the process determining C_0 the telescope is horizontal; during the process of levelling by reflexion it is pointed towards the nadir, and during the process of observing transits for longitude it is pointed nearly towards the zenith. Now although these processes are accurate enough in themselves, we have no means of knowing that the line of collimation remains immovable during these pointings."

Let C_0, when determined I. P. E., be called C_E, and when determined I. P. W., C_W. Until quite lately I had always attributed the constant difference between C_E and C_W to "unsteadiness." The characteristics of this difference are, (i) it remains invariable at any one station; *i.e.*, C will lie between, say, 1,610 and 1,612 and C_W between 1,616 and 1,618, for a whole month: (ii) at the next station the difference may have completely altered; in fact C_E may now lie between 1,616 and 1,618 and C_W between 1,610 and 1,612: whatever the new difference is, it will remain equally constant at the new station.

As an example, take the arc Deesa-Mooltan. Colonel Strahan at Deesa determined the value of both C_E and C_W nightly, the instrument being reversed in its Y's every night of the measurement at the middle of the work—

	C_E.	C_W.
First night	2,617·1	2,625·8
Second "	16·8	25·3
Third "	17·3	25·0
Fourth "	17·3	25·8
Fifth "	17·5	25·7
Sixth "	17·0	25·1
	2,617·2	2,625·5

On the arc following Deesa-Mooltan, *viz.*, Agra-Amritsar, which was measured in the same month, Colonel Strahan at Agra with telescope No. 2 found that his value of C_x was 2,628·6 and that of C_W 2,626·4.

The theory that the C_E and C_W difference is due to "unsteadiness of C_o" means that the change from C_E to C_W is *real* and not due to some constant error affecting the determinations. It means that, owing to a shakiness of the telescope the line of collimation at Deesa *did actually change* its inclination to the rotation axis eight divisions regularly backwards and forwards every time the telescope was reversed in its Y's. No instrumental defect, such as can be included under the terms "infirmity," "weakness," "looseness," "shakiness," could be so regular in its action as to make C_o vary *from* 2,617 to 2,625 on each of the six reversals from I. P. E. to I. P. W., and back again from 2,625 to 2,617 on each of the six reversals from I. P. W. to I. P. E. If, moreover, any unsteadiness in C_o really existed, could the several values of C_E and C_W have been so accordant *inter se*? Could, too, this unsteadiness have had one constant effect and an opposite but equally constant effect two weeks later at Agra?

In the season 1881-82, telescope No. 2 was shaky: this was clearly proved not by the C_E and C_W differences, but by the great discordance in the several individual values of both C_E and C_W. One cannot distinguish too strongly between *variations* in the *several* values of C_E and C_W and differences *between* C_E and C_W: the former prove the existence of unsteadiness; the latter do not.

At Jubbulpore in February 1890 I was much astonished at discovering that the difference between C_E and C_W varied with the angle that the optical axis of the collimators was inclined to the horizon.

In putting up the collimators their upper surfaces are approximately levelled with a spirit-level, but no attempt is made to level their optical axes: when both collimators have been put up for the first time and levelled, their two crosses will be found at different heights: they are brought to the same height by means of the foot-screws of the two collimators: the angle of the collimators is therefore always a matter of chance, and so unimportant is it considered that it is never measured. At many stations the collimator pillars are not of the same height, and mutual vision would therefore be impossible if the collimators themselves were placed horizontal: the pillars, which are thirty feet apart, are both raised to a certain height from the ground-level, so that the slope of the latter is repeated in the line joining their upper surfaces.

Further experiments at Mooltan in March 1890 shewed that at one inclination of the collimators C_E was greater than C_W and that at another C_W was greater than C_E: and that by gradually moving the collimators' small amounts at a time, a particular inclination about $0^{\circ}7'$ could be found, at which C_E and C_W were equal.

From these results it appears that the difference between C_E and C_W is due, not to unsteadiness, but to errors in the determinations.

When an observer can get any number of different values for both C_E and C_W merely by tilting his collimators, the question arises—What value of C_o should be adopted in deducing the collimation constant?

At Kurrachee, on April 6th and 7th, 1890, the following values for C_o were obtained with telescope No. 1:—

Angle of collimators.	C_E.	C
+15′	1,720·6	1,724·3
+ 3′	22·5	24·0
−10′	25·8	22·1

What value of C_o should be adopted in reducing the star transits obtained on those dates?

On the understanding that the changes in C_o are apparent and not real, the difficulty may be overcome by using the *same* value of C_o both with transits taken I. P. E., and those taken I. P. W. The collimation constant for I. P. E. transits is $(C_o - C_s)$ and for I. P. W. transits $(C_s - C_o)$: the level correction constant for I. P. E. transits is $(C_o - M)$ and for I. P. W. $(M - C_o)$: the effect then of any error in the adopted value of C_o will be cancelled in the mean result of the I. P. E. and I. P. W. transits.

It is a matter of indifference what value of C_o be adopted, provided the *same* value be employed both I. P. E. and I. P. W. The mean values of all determinations, whether taken I. P. E. or I. P. W., though not necessarily correct, is the one that had best be used in future.

Provided that a telescope remains in one pivot positon, either I. P. E. or I. P. W., the final result will be unchanged, whether a mean value of C_o as determined in that pivot position be employed or individual values: the latter method entails extra labour in computation, but is somewhat advantageous in that, if change in C_o is real, it renders individual results accordant and comparable *inter se*.

If, however, the telescope is reversed in its Y's, the direction of its micrometer readings is changed, and the final result will be different according to whether the same value of C_o be used before and after reversal, or whether one value be employed before and another after. With I. P. E., as the micrometer reading *increases* from 0 to 2,000, the centre wire moves from east to west: with I. P. W., its movement from east to west is accompanied by a *decrease* in the micrometer readings from 2,000 to 0.

Suppose $C_E = 1{,}642{\cdot}0$, $C_W = 1{,}646{\cdot}0$, the mean being 1,644·0. With I. P. E., the centre wire, when the micrometer reads 1,642, is two divisions *east* of its position, when the reading is 1,644. With I. P. W., the centre wire, when the reading is 1,646, is also two divisions *east* of its position, when the micrometer reads 1,644. So that if the two values

are used, the centre wire will be *throughout* two divisions *east* of the position it would occupy if one value were employed. As C_o enters into both the collimation and level corrections, the resulting value of ΔL when worked out with a mean C_o will differ from its value when reduced with C_B and C_W by 0·100, a far larger quantity than we expect any circuit error to attain to.

It appears now that our circuit errors have been mainly due to the employment of different values of C_o for I. P. E. and I. P. W. transits.

All the arcs measured since 1885 have been recomputed this summer by the new method, *viz.*, with a mean C_o per arc. The resulting diminution of the circuit errors is shewn in the following tables :—

(1) Arcs measured in the Punjab.

Circuits.	Closing errors of circuits.	
	When arcs are reduced by the old method.	When arcs are reduced by the new method.
	s	s
Dehra-Agra-Amritsar	0·023	0·033
Agra-Amritsar-Mooltan	0·251	0·013
Agra-Deesa-Mooltan	0·257	0·030
Amritsar-Peshâwar-Mooltan	0·033	0·019
Deesa-Mooltan-Kurrachee	0·325	0·056
Mooltan-Quetta-Kurrachee	0·018	0·079
Agra-Deesa-Kurrachee	0·109	0·081
Agra-Mooltan-Kurrachee	0·205	0·004
Agra-Amritsar-Mooltan-Deesa	0·508	0·017
Agra-Amritsar-Mooltan-Kurrachee-Deesa	0·183	0·075
Agra-Amritsar-Peshâwar-Mooltan	0·384	0·032
Dehra-Amritsar-Mooltan-Agra	0·274	0·020
Agra-Amritsar-Peshâwar-Mooltan-Deesa	0·541	0·002
Dehra-Amritsar-Mooltan-Deesa-Agra	0·531	0·050
Dehra-Amritsar-Peshâwar-Mooltan-Deesa	0·564	0·031
Mean closing error	0·281	0·036

(2) Arcs measured in Central India.

Circuits.	Closing errors of circuits.	
	When arcs are reduced by the old method.	When arcs are reduced by the new method.
	s	s
Jubbulpore-Agra-Kalianpur	0·174	0·017
Jubbulpore-Kalianpur-Bombay	0·143	0·052
Agra-Deesa-Bombay-Kalianpur	0·031	0·004
Mean closing error	0·116	0·024

(3) Arcs measured in Southern India.

Circuits.	Closing errors of circuits.	
	When arcs are reduced by the old method.	When arcs are reduced by the new method.
	s	s
Madras-Nagarkoil-Mangalore	0·074	0·017
Madras-Nagarkoil-Bangalore	0·064	0·036
Bellary-Bombay-Mangalore	0·101	0·057
Madras-Bellary-Bangalore	0·122	0·075
Madras-Bellary-Mangalore	0·088	0·018
Madras-Bellary-Mangalore-Nagarkoil	0·162	0·001
Nagarkoil-Bangalore-Bellary-Bombay-Mangalore	0·119	0·017
Nagarkoil-Bangalore-Bellary-Mangalore	0·220	0·040
Mean closing error	0·119	0·033

TIDAL OPERATIONS.

Extract from the Narrative Report of MR. CHARLES WOOD, *in charge No. 25 Party—Season 1889-90.*

* * * * * * * *

It may be generally stated that with the exception of only one observatory, all the others have during the current year been inspected, and the instruments and apparatus thoroughly cleaned, repaired, and adjusted, where necessary, with the result that there have since been practically no interruptions in the work. It was not found practicable to inspect the observatory at Kurrachee, owing to press of work in other directions; but by sending suitable instructions to the Engineer in charge of the harbour works, the necessity was obviated. The observatory will, however, be visited during the next few months.

The several descriptions of work will now be treated of in detail.

TIDAL OPERATIONS.

The following observatories have been at work during the year under report:—*Aden, Kurrachee,* Bhávnagar, *Bombay* (Apollo Bunder) *Bombay* (Prince's Dock), Cochin, Colombo, Galle, Tuticorin, *Madras,* Cocanada, *Kidderpore,* Chittagong, Akyab, *Rangoon,* Mergui, and *Port Blair.* Of the permanent observatories (those italicized), that at Madras has been closed for reasons given hereafter; but the others will continue till satisfactory registrations extending over a complete cycle of years have been secured. The dates of starting these observatories, as well of the temporary ones, are subjoined for convenience of reference:—

Aden—March 1879.
Kurrachee—January 1881.
Bhávnagar—January 1886, but satisfactory observations did not begin till December 1888.
Bombay, Apollo Bunder—January 1878.
Bombay, Prince's Dock—September 1888.
Cochin—January 1886.
Colombo—February 1884 (closed March 1890).
Galle—April 1884 (closed April 1890).
Tuticorin—January 1888.
Madras—February 1880.
Cocanada—March 1886.
Kidderpore—March 1881.
Chittagong—June 1886.
Akyab—May 1887.
Rangoon—March 1880.
Mergui—March 1889.
Port Blair—April 1880.

The observatories at Galle and Colombo completed a six years' run in April last,—the sixth year having been found necessary because of certain defective and unsatisfactory observations during one of the previous years. The instruments at these places were carefully examined, on the occasion of the inspection by the officer in charge and Mr. Belcham, in January last, and such of them as, after the attention they then received, were thought to be in sufficient order to warrant their being used at Minicoy and Trincomalee, were left in charge of the Master Attendant at Colombo, when the observatories were dismantled in April last; the remainder were brought away for necessary repairs. No other observatories have completed their period during the year.

In accordance with instructions, advantage was taken last January to prospect Trincomalee in Ceylon, for the erection of an observatory, and to arrange with the Superintendent of light-houses (Lieut. A. Channer, R.N.) for a passage to Minicoy for a similar purpose.

After inspecting the Master Attendant's jetty at Trincomalee, the naval dockyard was examined, by the kind permission of the authorities, and a suitable spot was fixed on. In addition to the eligibility of the spot, the advantages of having an observatory there were enhanced by the ready and courteous offer of Mr. E. A. DeRidder, the naval storekeeper, to not only have the building put up for us when required, but to supervise the work of the observatory clerk, when the instruments were placed in position. Of course no action could be taken until the sanction of His Excellency, Rear Admiral the Honourable Sir E. R. Fremantle, K.C.B., Commander-in-Chief, Her Majesty's Indian stations, then away on duty in Zanzibar, was obtained. In due time, however, as was fully expected, the sanction was received; and, thanks to Mr. DeRidder and his staff, the observatory is completed, and there is every prospect of its being in operation in October.

As regards Minicoy, the Trinity Board having very kindly offered all help in their power towards conveying our working-party to Minicoy and bringing away the records, etc., from time to time, Lieutenant Channer, R.N., was interviewed so as to settle preliminaries for the inspection of the island. It was found that his date of departure from Colombo (early in February) would not suit our programme at all; but he very kindly offered to delay his departure for a fortnight for us, and this was just what was needed. Mr. Belcham was thus enabled to get to Minicoy in February, and after thoroughly prospecting the place he came back with Lieutenant Channer in his vessel, the S.S *Ceylon.* His report, extracts from which are subjoined, is very complete, and as Minicoy is a truly oceanic station, we may hope for a specially valuable set of tidal registrations thereat. The difficulties of communication between visits, and especially during the monsoons, will

always be a source of anxiety, and, therefore all that can be done towards securing permanency in the working of the instruments will be done at the outset. The island is, moreover, reported to be unhealthy during the monsoons, fever and rheumatism being prevalent, and the light service actually buried four and discharged three keepers in two years! At Lieutenant Channer's suggestion, I am taking every precaution to ensure the health of the clerk, but I recommend an interchange of duties between the clerks at Minicoy and Trincomalee from time to time. Full advantage was taken, when dismantling the observatory building at Colombo, to repair and renew it where necessary and leave it packed up ready for transport at short notice; and opportunity will be taken of Lieutenant Channer's next visit to Minicoy to take over as much of the *impedimenta* as practicable, so as to leave his vessel free for transporting the instruments and work-people who will accompany Mr Belcham when he proceeds to the island after starting the observatory at work at Trincomalee. I cannot close this part of my report without placing on record my best thanks to Captain Donnan, the Master Attendant at Colombo, both for his kindness in storing our tidal observatory kit at his office, and for his readiness to assist us by buying at Colombo some additional apparatus that we shall need at Trincomalee and Minicoy. I may mention here that the late clerk at Galle, Mr. Sarasingha, a Cingalese with plenty of intelligence, has been retained for employment at Trincomalee; and Mr. Francis, a steady and experienced young man, has been transferred from Cocanada, through the courtesy of the Port authorities, from 1st October for employment at Minicoy.

Instructions were also received to prospect Diamond Island at the mouth of the Bassein river, for the establishment of a gauge there. Without neglecting the wants of other observatories, opportunity was found for doing this last April on Mr. Belcham's return from Port Blair. The Burma Government had been previously asked to direct the Executive Engineer Bassein, to accompany Mr. Belcham, and this was readily accorded. Mr. Belcham went over the island with the Executive Engineer, Mr. Wollaston, and brought back a favourable report on the suitability of the island for the purpose, the cost of erecting the observatory being roughly estimated at ₹2,500. The Burma Government has directed the Bassein Municipality to meet this expense, and has undertaken the maintenance of the observatory establishment. The requisite plans, etc., have been forwarded to the Burma Government to place in the hands of the Public Works Department for the construction of the observatory building, and it is confidently expected that during the coming winter the tide-gauge at this place will be in full work.

Penang was next in order for a tide-gauge, but it was found that there was one there already at work under the Colonial Government, and that the results were worked out in England by Mr. Roberts of the Nautical Almanac Office. The Persian Gulf was therefore turned to; and in compliance with orders, enquiries and references have been set on foot with a view to ascertaining the cost of erecting the observatories and maintaining the working establishment at Jashk and Bushire: it is thought, however, that a personal visit is necessary, and advantage will be taken during the coming winter, when inspecting Kurrachee, to go on and select a site at both of these places

Regarding the observatory at Shiyálbet, now known as Port Albert Victor, in commemoration of the Prince's visit to the place in March last, it was hoped that it would be in operation during this year; but, I regret to say, that, owing to the sudden death of Mr. Beck, one of the State Engineer's assistants, and the absence on leave of others, as well as State affairs, which needed all the attention of the Engineer himself, nothing has yet been done. Mr. Proctor-Sims, the State Engineer, whom I saw a few weeks ago when inspecting Bhávnagar, informed me that the State works at Shiyálbet would certainly be taken in hand in November next, which include *inter alia* the tidal observatory. I hope, therefore, that the observatory will be in operation early next year.

Of the fifteen observatories at work at the close of the year under report, three, *viz.*, Cochin, Cocanada, and Chittagong, will complete their appointed period during the coming survey year, the first in February, and the other two a few months later. As, however, it is certain that the Persian Gulf stations will not be ready till late next year, the continuance for another year of the Cochin work is very desirable (so as to make up for the unsatisfactory registrations in 1887), leaving Cocanada and Chittagong (both of which might be dismantled at the same time in June) to supply the instruments for Jashk and Bushire.

Not including Okha, Hanstal, and Navánár (Nowanar) at which, generally speaking, only a year's registrations are available, and Shiyálbet, where they were taken for 13 lunations, by personal observations on a graduated staff at every quarter of an hour, we have now fifteen closed observatories and fourteen at work. It is very desirable that at all the closed observatories a graduated staff, set to the zero of the gauge, should be erected, to admit of comparing the predicted values of time and height of high and low-water with the actual values. The only port at which such an arrangement is at work is Moulmein; and the tables of such comparisons for a year are sent to Mr. Roberts to utilize in correcting his predictions, where necessary.

With the exception of the riverain ports in the Hooghly (*viz.*, Diamond Harbour, Kidderpore, and Dublat), the riverain ports in Burma (*viz.*, Elephant Point, Rangoon, and Moulmein), Kurrachee, Bombay, and False Point,—where the datum to which the predictions refer is the same as that *locally* adopted by the river surveyors, etc., and Amherst, the survey datum for the tide-tables is the Indian spring low-water mark. This does not differ materially from that adopted generally by the Admiralty for chart soundings, and

a statement shewing how our datum compares with the others is subjoined for convenience of reference:—

Comparison between datum as adopted for the Tide-tables and that adopted for chart-soundings.

Observatory.	Tide-tables datum. (1)	Chart-sounding datum. (2)	(1) higher + (2) lower −
Aden	Indian spring low-water mark.	Mean low-water, ordinary springs.	+4″
Kurrachee	Harbour works datum.		*Nil.*
Okha	Indian spring low-water mark.	Mean low-water, ordinary spring tides.	+5″
Káthiwádar			+5″
Bhávnagar			−8″
Bombay (Apollo Bunder)	Mean low-water, ordinary spring-tides.		*Nil.*
Bombay (Prince's Dock)			*Nil.*
Mormugáo	Indian spring low-water mark.	Mean low-water, ordinary spring-tides.	+5½″
Kárwár			+2½″
Beypore			+1″
Cochin			−½″
Tuticorin			−3½″
Colombo			+1½″
Galle			*Nil.*
Pámban			*Nil.*
Negapatam			+2″
Madras			+1′ 9½″
Cocanada			−1′ 8″
Vizagapatam			+4″
False Point	Petley's datum, *i. e.*, lowest low-water, 1881-85.		*Nil.*
Diamond Harbour	Kidderpore Dock-sill or River Surveyor's chart datum, *i. e.*, mean low-water, ordinary spring-tides.		*Nil.*
Kidderpore			*Nil.*
Dublat	Kedgeree gauge zero or River Surveyor's chart datum.		*Nil.*
Chittagong	Indian spring low-water mark.	Low spring-tides, November to April. Low-water, ordinary spring-tides.	−1½″
Akyab			+1″
Elephant Point	Marine Survey chart datum, or very nearly lowest recorded low-water = 24 feet below B. M. A.		*Nil.*
Rangoon	River Surveyor's chart datum, *i. e.*, within 3 inches of Marine Survey chart datum.		*Nil.*
Amherst	Mean low-water, ordinary springs, *i. e.*, 31·288 feet below Marine Survey B. M.	29′ 5½″ below Marine Survey B.M.	+2′ 10″
Moulmein	Marine Survey chart datum, *i. e.*, 23·335 feet below B. M. A., or 2 feet 8 inches below mean low-water, ordinary spring-tides.		*Nil.*
Port Blair	Indian spring low-water mark.	Mean low-water, ordinary spring-tides.	+5″
Mergui		Ditto ditto May to July.	+6″

NOTE.—The Tide-tables above referred to are those for 1890, for all the observatories except Mergui, which will, for the first time, appear in the tables for 1891.

A brief notice of the working of each observatory, following in order round the coast, will now be given.

Aden.—The instruments have worked fairly well throughout the year, but owing to the *mala fides* and unpardonable carelessness of the clerk between December and April, the registrations for this period are not nearly as trustworthy as before, and 12 weeks' tidal work and 7 weeks' barographs and anemographs have had to be rejected. Fortunately, the work to be rejected comes just after the completion of a working year; and so the evils have been averted to some extent by changing the date of the next working year to 31st May, which is the date on which the modified gauge began work regularly.

Aden has this year been favoured with a few occasional showers, and when inspected in the end of May the hill sides actually presented a green appearance.

The clerk has been dismissed, and a new man appointed by the Port Officer. The tide-gauge sent out modified and repaired by Légé & Co. was found all that could be desired. It was set up on the 30th May, and during the next fortnight the clerk was thoroughly drilled in his work, the working of the new gauge tested, and the old one packed up for despatch to England, to be similarly treated by Légé & Co. Fortunately, the self-registering aneroid and anemometer, sent out by Légé & Co. at the same time as repaired,

were not needed at Aden, as the instruments there were in good working order; for when they were opened out at Poona, from defective packing the aneroid was so knocked about in its internal case as to look a perfect wreck. After a fortnight's patient examination and repair, it was set right; but there was abundant evidence that neither this instrument nor the anemometer (which needed and received sensible alterations here) had been set up and tested before despatch from England. The testing of instruments before despatch to India cannot be too strongly insisted on.

The mercurial barometer, which, after repair at the Mathematical Instrument Office, was set up in June 1889, was compared with the standard when the observatory was recently inspected, and found to have a small but fairly constant index error.

Kurrachee.—At this observatory the float-end wire broke on one occasion, and the float-band on another. The necessary repairs were executed under the supervision of the Port Engineer, to whom the required instructions for the taking of zero-measurements, etc. were sent. The clock of the gauge as well as the anemometer were also cleaned under the Engineer's supervision. Though imperfect communication with the outside water was noticed half-a-dozen times, the interruption on account of it was of very short duration each time. On the 7th, 8th and 9th June 1890, owing to cyclonic weather, there was an abnormal rise of the tide, high-water standing on one occasion at as much as 2 feet above that predicted.

Bhávnagar.—This observatory was inspected in November 1889. As usual, all the instruments were thoroughly overhauled; a new sheave-wheel and float-band were put on at the same time. The working of this gauge had been very peculiar till December 1888, the curve at high water being quite flat, and the rush at the turn of the tide much too rapidly shown on the diagram. Colonel Rogers attributed this to the presence of air in the connecting tube, and arranged for the opening of the air cock in the cylinder at *every* high water, and keeping it open for four to six hours, whereas formerly it was only opened for a few minutes at one high water: since this, the curves traced have been remarkably symmetrical and the results of the registrations markedly improved. The cylinder continues to be flushed regularly about once a fortnight. The interruptions at this observatory have been very trifling indeed, thanks to the close supervision exercised by Mr. R. Proctor-Sims, the State Engineer. The self-registering aneroid not having worked satisfactorily, and it being necessary to see Mr. Sims regarding the delay in constructing the Port Albert Victor (Shiyálbet) observatory, I determined to antedate the next inspection of Bhávnagar by a few months. The instrument recently received from Légé & Co. and repaired in this office was accordingly taken over by me in the end of August and set up in the observatory. The mercurial barometer, too, got out of order during the year; it was replaced by another. I am glad to say that the Bhávnagar State has generously responded to the representations of this office, and sanctioned the continuance of the observatory at this place till five years' satisfactory registrations, beginning from December 1888, have been secured. This concession, as well as the liberality of the State in undertaking the entire cost of erection and maintenance of the observatory at Shiyálbet, call for hearty acknowledgments not only from this department but from the authorities at home interested in the question of tidal phenomena, for Bhávnagar is unique, so far as the Indian waters are concerned, for the great range (36 feet) of its tides.

Bombay (*Apollo Bunder*).—The self-registering tide-gauge at this observatory has worked very well during the year. Being on the way to Aden, Bhávnagar, etc., opportunity is taken by the officers of the party to visit the observatories at Bombay whenever they happen to be passing through. Thus, in addition to the regular inspection in November 1889, when the whole of the apparatus was thoroughly overhauled as usual, the observatory was again visited by myself and Mr. Belcham in May, when he was going out to Aden. I found, from the comparisons of actuals against predicted values, that indications of retardation were just beginning to be apparent, and I directed Mr. Belcham to examine carefully on this point when he returned from Aden. His report showed that there was certainly a deposit of silt, 3 feet in depth, at the bottom of the well; and had this not been discovered in time, the heavy roll of the sea in the monsoon would have increased it so as ere long to vitiate the registrations by reaching the zero of the gauge. The Engineer was therefore asked to open up the floor of the observatory; and it was then found by him that five cart-loads of mud had accumulated at the bottom of the well, and these were removed at once. To prevent any risk from unexpected accumulation, the Engineer has been requested to observe it as a standing rule, that similar clearing out be taken in hand on the 1st June and 1st November of each year. The graduated staff, by which the gauge readings are roughly checked daily, has broken four or five times during the year under report: it can be readily repaired, and so little or no inconvenience is experienced.

As mentioned in previous reports, there are no meteorological instruments attached to this observatory.

Bombay (*Prince's Dock*).—The gauge at this observatory is different from those in use elsewhere: the cylinder is upright and the paper is given off and received by two auxiliary cylinders. A general description will be found at page xii of the Appendix to the Annual Report for 1887-88. During the year under report, the observatory was regularly inspected in November last, and casually in May. On four different occasions the paper got twisted for a few hours and so fell below the pins on the top of the central cylinder which keep it correctly in position; this was suitably remedied and has not occurred since. On two occasions the float-band stuck on the stud-wheel, causing interruptions of 14 hours

and 4 hours: and there is one break of nearly two days due to stoppage of the clock. Besides these, there have been no interruptions in the work; and the results look very promising. In the end of August, while on the way out to Bhávnagar, I again visited the observatory, in order to take such notes of the instrument, and obtain a diagram, as would enable a suitable description to be prepared therefrom for the hand-book of the department, which is under compilation at the head-quarters of the Deputy Surveyor-General, Dehra Dun.

This observatory, like that at Apollo Bunder, has no anemometer or barometer attached to it.

I am much obliged to Mr. Ormiston, the Port Engineer, and his assistant, Mr. Squire, for the prompt and efficient supervision which they exercise over the working of both the observatories in Bombay.

Cochin.—The record of the instruments at this observatory during the year under report is a remarkably uninterrupted one. Except the short break in the registrations, of only three or four hours, when the gauge and its clock were taken down for cleaning at the inspection of the observatory by myself last January, there is not a single interruption in the register of the gauge. In March, the rose at the end of the communication pipe corroded and fell off, and in its place was substituted a basket, which seems to answer well enough. The clock has behaved better this year than before, though its rate continues somewhat irregular; this, however, is of no consequence, as the error is corrected daily by the clerk

The anemometer has only three breaks in its record (besides the short interruption of four hours when it was dismantled for cleaning during the inspection); *viz.* one of two days when the jewel near the lever of the clock fell off, and two of about 14 hours' duration, each due to stoppage of the clock.

The record of the self-registering aneroid is complete, there being no interruptions whatever, excepting the necessary one of some 3½ hours when the instrument was being cleaned.

To the Port Officer, Captain Winckler, our acknowledgments are due for the efficient supervision which he exercises over the proper working of the observatory.

Colombo.—As mentioned in the Annual Report for 1888-89, the bed-plate of the self-registering tide-gauge was, on the inspection of the observatory in June 1889 by Mr. Belcham found to have settled 0·074 feet. On the 3rd of September, however, some cargo boats dashed against the observatory and started it from its position. It was immediately seen to by Captain Donnan, who, after he had replaced it in position, applied to the Surveyor-General's Department in Ceylon to have the difference in height between the bed-plate and the reference bench-marks carefully levelled: this was done, with the result that the bed-plate was found to have risen 0·063 feet by the accident, and to have thus considerably overcome the settlement of the year before. When inspected in December 1889 by myself and Mr. Belcham, the rise was ascertained to have been 0·056 feet, and the gauge was found dirty. It was dismantled, and after being thoroughly cleaned was reset up. An examination of the diagrams led to the result that the registrations for the period, 21st October to 18th November 1889 had to be rejected on account of retardation caused by the choking of the inlet holes, as evidenced by the abnormal differences between the actual and predicted values: besides these, there have been two trifling breaks in the records of 11 and 15 hours.

The observatory was dismantled on 29th March 1890 by Sub-surveyor Dhondu Venayek, who took the usual zero-measurements before removing the gauge. The planking, etc., of the observatory building was repaired in accordance with orders; and it, together with such portions of the instrumental equipment as were in working order and capable of standing another term of work, were stored in the Master Attendant's office, for use at Minicoy: all these have just been taken over to the island by Lieutenant Channer, R.N., Superintendent of the Light-house Service; and Mr. Belcham will very shortly proceed to start both the new observatories at Minicoy and Trincomalee.

As the office of the Surveyor-General of Ceylon regularly takes and records meteorological observations, there was no necessity for either barometer or anemometer at this observatory.

Galle.—The working of this observatory since the inspection in June 1889 has been very satisfactory. A reference to the Annual Report for 1888-89 will show that, owing to the coming away of the bottom of the iron cylinder and the enlargement of the ingress and egress holes, the pencil moved up and down incessantly over six or seven tenths of a foot. This simple statement, however, gives no idea of what the diagrams represent for a period of nine weeks, rendering them most difficult to read and utilize, as has had to be done *this* year. At first sight, it almost seemed hopeless to try and trace the daily curves; for although each day's work is daily inked up with a *different* coloured ink, yet when the curve is formed not of a series of points but of a series of lines of varying lengths, and one day's curve on the paper overlaps those on either side of it in time, it becomes most difficult to manipulate. With much patience, Mr. Belcham, however, managed to get all that was required from the diagrams, and so no break occurs. The tidal registrations show an unaccountable peculiarity on the 23rd December last, which, having only very lately come under notice when reading the diagrams, cannot yet be traced to a cause; and hence, in my opinion, the necessity exists for a close examination of each batch of weekly, fortnightly, or monthly diagrams *immediately* on their receipt at the

office, so as to make timely enquiries regarding anything that may appear abnormal in them. The peculiarity referred to is the sudden, or rather instantaneous, rise of the water by 1 foot just after midnight of the 23rd December, followed by a drop of 7 inches, when another rise took place, of which the height cannot be determined; as the pencil was unable to go higher on the paper; these sudden rises and falls, relatively to each other, grew smaller and smaller, though the water maintained an abnormally high level for three hours, when, at the turn of the tide, there was a drop of over a foot in about half an hour, followed by an instantaneous rise of about 10 inches and an immediate fall to the same extent, after which all was quiet. The aneroid and anemometer registrations show absolutely nothing to account for this sudden swell and subsidence of the water during five hours, and I can only attribute it to seismic action; but it would be in the highest degree interesting to be able to trace it definitely to its prime cause. An examination of the Colombo registrations shows a small disturbance there of the same character between the hours of 1 and 3 A.M. Endeavours will be made by enquiries from suitable persons to ascertain any contemporaneous disturbances elsewhere.

The observatory was inspected by me in company with Mr. Belcham, on the 7th January, and everything found in good working order, except the mercurial barometer, the glass of which was found very fogged and difficult to see through, and the surface of the mercury in the cistern had a yellowish film on it. All that was necessary towards cleaning the instruments was done before leaving.

The observatory having completed its period of six years on the 8th April, Sub-surveyor Dhondu Venayek was sent down to dismantle it. The sub-surveyor took zero-measurements before removing the gauge. The observatory was sold by public auction and the instruments., etc., were carefully packed and brought away to Colombo, where the greater portion was stored in the Master Attendant's office for transport in due time to Trincomalee, the remainder being brought away to Poona for repair.

Tuticorin.—All the instruments at this observatory have worked most satisfactorily throughout the year the record being quite complete, except for a few hours during the inspection in December last by myself and Mr. Belcham, when the gauge and its auxiliaries, the self-registering aneroid and anemometer, were dismantled for the purpose of being cleaned. As Tuticorin is on the way to Colombo, Sub-surveyor Dhondu Venayek was directed to visit the observatory on his return, and to take a set of zero-measurements for comparison with those taken by me in December and as being near the close of the working year of this observatory; the result was very accordant; for while the December observations gave the working zero of the gauge as 11·736 feet below the bed-plate, those in May gave this as 11·738 feet, where it must be stated that each is the mean of 20 rising-tide and as many falling-tide measurements.

The general supervision of the observatory is in the hands of Captain Baker, the Port Officer, who is always ready to afford us every assistance in his power.

Madras.—I regret to notice that the tide-gauge at this observatory has, during the last three years been yielding such unsatisfactory results as to be nearly useless for the purpose which they are intended to serve. In February last the diagrams for the years 1888 and 1889 came under scrutiny for reading off, and the exceedingly unreliable character of the work was only then brought to light. Owing to the very rough water in which the cylinder of the gauge had necessarily to stand, a special arrangement for the ingress and egress of the water had to be resorted to in order to get any results at all; this arrangement has not answered as satisfactorily as was expected, and the Madras gauge has always been a more or less troublesome one to keep in working order. The working year of this observatory began on 1st February: for the year 1888-89 there were two months (February and March) of very bad work indeed, the retardation being represented in time by as much as two hours; and for the year 1889-90 there were no less than six months' bad work (May to October 1889) in which the retardation in time gradually went up from one hour to two and-a-half hours. During this period (*i.e.* from 1st February 1888 to 1st February 1890) the gauge cylinder was overhauled on three different occasions, *viz.* March 1888, March 1889, and October 1889, in order to clear off the choking, and this is by no means a light undertaking, for it involved the removal of a portion of the roof of the observatory in order to get up the cylinder and float. Considering the unsatisfactory character of the registrations I determined upon rejecting the observations for the two periods before stated, but thought it as well to get the benefit of Colonel Rogers' opinion on the point; I therefore prepared a table, showing how the actuals in time and height compared with the predicted values, and took the opportunity to see him on the subject when inspecting Kidderpore last March. He not only fully agreed with my conclusions, but gave it as his opinion that the doubtful results which could at best be got from the observatory in its present position did not warrant the trouble and expense of their reduction, and that their introduction into the data whereon the future predictions for this port were to be based, so far from improving them, would, from their erroneous and doubtful character, impair the accuracy of the data on which the predictions had till now depended. Accordingly, on my return from Burma in May, I addressed the Deputy Surveyor-General on the subject, recommending the discontinuance of the observatory as at present existing, and the establishment of another, if required, on a more suitable site and of a design to secure the carrying down of the cylinder *sufficiently low to be below the rough surf action.* The matter was laid before Government, and by them was referred to the Government of Madras, with a view to ascertaining whether they wished for a continuance of the tidal observations and were

willing to bear the expense of erecting a new observatory at a roughly estimated cost of R8,000. Orders have just been received that the continuance of the observatory is no longer required; but I regret that a little undue haste on the part of the authorities responsible for the repairs to the pier-head, induced the Presidency Port Officer to actually close the observatory on the 10th October, before apprising me of it. It should be mentioned here that after rejecting the untrustworthy registrations of 1889, I changed the initial date of the working year from 1st February to 20th October; and so the continuance of the observatory till the beginning of next month (for we reckon 371 days in our working year) would have secured a complete year's work, which would have been amply good enough to incorporate with the fairly trustworthy data of former years.

The observatory was inspected last January by Mr. Belcham. He found that the tide-gauge needed cleaning, and that the working zero stood at 24·863 feet below bed-plate instead of 25·328 feet as originally adopted and since maintained. After ascertaining that the bed-plate itself had not altered in height (by levelling from it to the reference bench-marks), he traced the difference to an increase in the weight of the float when the cylinder, etc., were overhauled for cleaning and reset up on the 28th October. Had there been a graduated staff here, as at other observatories, such an error could never have passed undetected for so long a time.

An aneroid barometer (by Adie) was on this occasion set up in the observatory in place of that which had to be taken away in July 1889, as mentioned in the Annual Report for 1888-89.

Cocanada.—The self-registering tide-gauge at this observatory has worked particularly well throughout the year, and when the place was inspected last January by Mr. Belcham, the gauge and its clock were found quite clean and only needing a little oiling. The zero-measurements showed that the working zero corresponded almost exactly with the true zero.

The mercurial barometer too was found in good order; but the self-registering aneroid (by Adie) which had been brought away in May 1889 for repairs, and was sent down from Poona in January, was found to be still very insensitive, owing probably to its needing a new hair-spring. It has in consequence been inoperative throughout the year.

The anemometer at this observatory has worked well throughout the year, having only a single interruption of three hours in its record.

Thanks to the courtesy of Captain Street, Presidency Port Officer, and of Captain Wicks, the Port Officer at Cocanada, the services of the clerk at this observatory have been placed at the disposal of the Survey Department from 1st October for employment at Minicoy, and satisfactory arrangements made for the carrying on of the work by the local meteorological observer. A better selection could not have been made for Minicoy, as the clerk is an intelligent and energetic young man who takes with him some years' experience in the work of a tidal observatory.

Kidderpore.—The self-registering tide-gauge at this observatory has an almost uninterrupted record for the year under report, the only breaks being one of three hours, two of twelve hours from stoppage of the clock, and a fourth of a few hours when the instruments were dismantled for cleaning during the inspection by myself in March last. The working-zero has remained wonderfully constant throughout the year.

The clock of the self-registering aneroid kept stopping between the 12th and 18th January last; it was then removed for cleaning by a mechanic of the Mathematical Instrument Office, and re-started on the 21st idem, since which time it has gone uninterruptedly. Except the interruptions during the dates mentioned there is not a single break in the record of this instrument during the year. The mercurial barometer has worked very well indeed.

In the record of the self-registering anemometer there is a break of a fortnight, 8th to 21st May, due to one of the fans having been carried away and the upper part of the instrument needing repair. This was seen to by Lieutenant Petley, R.N.; and our thanks are due to him for the careful supervision which he continues to exercise over the general working of the observatory.

Chittagong.—This observatory was inspected by me in the middle of March last; it was found to be in a condition satisfactory and the instruments all apparently in good working order. The clock here easily alters its rate. During the year under report there are eleven occasions on which it was found to have an error of over three minutes—the maximum error which is inappreciable on the diagrams—and the necessary corrections will have to be made before reading the hourly curves.

The self-registering tide-gauge seems to have worked very well till the beginning of December, when the clock stopped and had to be given to a local watchmaker for repairs. It was re-started after a week, and since then has only stopped once, for four hours. The only other interruptions in its record are on five occasions when the pencil failed to mark for three or four hours at a time, and on two days for a similar interval when the gauge and clock were dismantled for cleaning during the inspection.

The mercurial barometer and self-registering aneroid have worked well throughout, there being only five short breaks of two or three hours at a time in the register of the latter due to stoppage of the clock. It has, however, gone uninterruptedly since it was cleaned in March last during the inspection.

The self-registering anemometer has worked most satisfactorily and has not a single break in its record during the year.

Akyab.—This observatory was inspected by me in the end of March last, and I was

well pleased with its orderly appearance and with the working order in which I found the various instruments. In consequence of the illness of the clerk there is a break of three days in the work of the self-registering tide-gauge; and from the stopping of the clock there are five breaks of from four to eight hours. Owing to my detention here for a week, I was able to rate the clock very satisfactorily. The midday gun is fired daily by the time indicated by this clock, and a note is immediately after despatched by the Telegraph Office to the Port Officer, stating how many seconds the gun was in error: by this means the clerk is able to check the error of his gauge clock and to correct it when necessary, and it is satisfactory to see that for days together no correction is necessary. A new sheave-wheel and chain were substituted for the ordinary wheel and wire to hold the pencil-traveller, and the instrument left in thorough adjustment.

The mercurial barometer, the self-registering aneroid, and the self-registering anemometer have all worked most satisfactorily throughout the year, not a single break (barring of course those for a few hours when the instruments were dismantled for cleaning during the inspection) appearing in the record of the latter.

Rangoon.—There is a marked improvement in the uninterrupted working of the self-registering tide-gauge during the year under report as compared with former years. On two occasions, the endless chain connecting the float with the counterpoise broke and got entangled in the bottom of the cylinder, causing short and unimportant interruptions in the registration of the curves; a new copper chain was made up at Poona and supplied, and I am glad to say there has been no recurrence of this kind of stoppage. The observatory was inspected by Mr. Belcham in April last, when on his way to prospect Diamond Island, and the gauge was found working very satisfactorily; but the zero-measurements then made showed that the working-zero stood at half-an-inch above the true zero, and the required correction will therefore have to be made when reading off the diagrams. Another bench-mark is wanted at this place in lieu of one that has been destroyed, and the Port Trust Engineer has kindly promised to have one put down in the vicinity of the wharf. During the inspection, the instrument was thoroughly overhauled, and a sheave-wheel and chain were substituted for the ordinary wheel and silver wire attached to the pencil-traveller: since then, there have been only three trifling breaks in the record, one of eleven hours due to stoppage of the clock, and two of two or three hours due to the pencil failing to mark.

The self-registering aneroid has certainly not redeemed its past bad character during the year under report. Owing to the stoppage of the clock, the gold thread coming off the wheel and breaking—horse-hair being substituted for it at times—and the general insensitiveness of the instrument, the registrations have been both interrupted and unsatisfactory. Possibly this is in some measure due to the vibration and concussion which is often very marked on the wharf, and so cannot be helped as long as the observatory occupies its present position. However, during the last month it has worked better after having been for the second time in the hands of the local watchmaker. During the inspection, it was taken down and a new hair-spring and gold wire were supplied, after which it seems to have gone well enough for about a month and a half.

The record of the self-registering anemometer is much more satisfactory, the only interruptions being one of 19 hours when during a very heavy gale in the end of March the clock stopped, and again of 8 hours due to the same cause, and also on two days when the instrument failed to register, owing to a screw-nut having worked loose; on another occasion, an equinoctial gale of more than ordinary violence blew off one of the direction fans from its holding, and for two days, until a new screw could be got, the instrument was driven by only one of the fans.

Our best thanks are due to Mr. Darlington, the Chairman of the Port Commissioners, and to Mr. Reichenbach, the Port Engineer, for the very prompt and efficient supervision which they exercise over the working of the observatory.

While at Rangoon last April on my way down to Mergui, I incidentally heard that it was in contemplation to have a time-ball set up in Rangoon to be worked by the Meteorological Department, and that, rather than have separate establishments for the meteorological and tidal work, it was under the consideration of the Port authorities to locate the tidal observatory in the same place that the tower for the time-ball and signal service would occupy. This, if carried out, will probably be just the opportunity that has been wanting to get a more suitable site for the tide-gauge than the present one.

Mergui.—This observatory was inspected by me in the beginning of April last just about 12½ months since the work was started. I found the observatory itself and the instruments all in good order, but a glance showed the cogent necessity for protecting the piles on which it stands, from the dashing against them of cargo boats, which are lashed up to the steps of the wharf, with their forepart sometimes standing well under the observatory and the side jammed up against one or other of the piles. Notwithstanding the notice put up by the Deputy Commissioner on the southern face of the observatory, warning off offenders in this respect, the evil was apparently one which the police could not keep down, as, according to them, it was impossible to land cargo at the wharf "without a portion of the boat itself being jammed up against the piles of the observatory." In the face of such adverse circumstances it is satisfactory to find that there were no serious interruptions in the working of the gauge itself, though several breaks occurred in the record of the aneroid; and the observatory has, for some months past, been placed beyond the reach of accidents from this cause, by the Department Public Works having put down substantial

booms or fender-piles, and so fenced in the piles of the building itself. At the inspection the working zero was found to be half-an-inch below true zero; the bed plate too was found out of level transversely, with the wire holding the pencil not stretched parallel to the sides of the groove within which the pencil-traveller runs. The instrument was taken to pieces, a new sheave-wheel and chain substituted for the former ordinary wheel and silver wire, and its various parts, including the clock, well cleaned, and then re-set up. An examination of the clerk's books for the year showed that there were three breaks due to stoppage of the clock, *viz.* one of sixteen hours, and the others of less than two hours' duration, and that there were three other short and insignificant breaks due to either jamming or breaking of the pencil. The time, which was solely dependent on a chronometer which had been left in the observatory for the purpose when the work was started was found to be in error by only 3′ 5″.; this is indeed fortunate, for had any stoppage of the chronometer occurred, or its rate, as determined in March 1889 altered largely, the registrations of the tide-gauge might have been sensibly impaired. To obviate this I asked for and obtained a sun-dial from the Deputy Surveyor-General's office, Dehra Dun, which has been set up in the compound of the Deputy Commissioner's office at a spot under the eye of the guard. At first sight, it might appear rather a crude way of checking time minutely by a dial, which can only show two minutes, but it is possible to do so to a few seconds in the following way:—

The dial having been placed approximately in position, a chronometer is held alongside, and when apparent noon is shown by the chronometer, the whole dial (which, in the present case, is of a novel design, by Colonel G Strahan, R.E., and rests on three foot-screws fitting into grooves cut into small circular pedestals, which can easily be shifted on the smoothened surface of the dial-pillar) is shifted until the light, which passes through a slit in the upper plate, is exactly bisected by the 12-o'clock stroke of the detached scale, which rests on the lower plate of the dial; this can be tested at each of the succeeding 2-minute strokes, and it will be found that the time read off from the dial is within 10 seconds of that indicated by the chronometer. The pedestals are then cemented in position, and the whole covered over with a removable box fitted with a padlock. It goes without saying, that the lower or dial-plate on which the scale rests, and the zero or 12-o'clock setting line, which has been exactly cut by the maker in the normal of the slit in the upper plate through which the light passes, must be *absolutely level*, and this is seen to every time that dial-readings are taken. The mean of several 2-minute readings taken by myself, as compared with corresponding chronometer-readings reduced to apparent time, was in error only five seconds, while a similar mean from readings taken by the clerk was nine seconds; and when it is considered that in this three distinct sources of error are present, *viz.* the orientating of the whole dial the setting of the 12-o'clock line of the scale to the zero-line on the lower or dial-plate, and the due estimation of the instant when the band of light is exactly bisected by the lines on the scale, the result is satisfactory beyond expectation. A table giving the proper equation of time for each day of the year was prepared and made over to the clerk, and the whole process of comparison carefully shown him. As it is undesirable to move the chronometer from its place in the observatory, a journeyman watch is, in the first instance, compared with the dial-reading corrected to mean time, and then taken down to the observatory (which is a few minutes' walk from it), for comparison with the chronometer-reading corrected for the error brought up by the rate deduced from several days' time-observations, and which has also been tabulated for each day; the error in the *corrected* chronometer-time is then known for that day, and this is used as a constant correction to the tabulated corrections before referred to, until, on the next occasion of comparison a fresh constant correction is obtained, and so on. Unfortunately, owing to the absence of sunshine during the past several months, the comparisons have been but few—the results are, however, very satisfactory, and, so far as can be judged, the chronometer is maintaining its original rate very well.

The self-registering aneroid has, I regret to say, not worked satisfactorily. In the year preceding the last inspection there were about 20 breaks (all short, fortunately) and since then 10 more in the registrations all due to stoppage of the clock. These instruments are very delicate, and, when once they begin to give trouble, it is difficult to set them right without bringing them away altogether. The mercurial barometer and the self-registering anemometer have yielded very satisfactory results, there being practically only a single stoppage worth noticing (of 23 hours) in the working of the latter.

Our thanks are due to Mr. H. G. Batten, Deputy Commissioner, for his courtesy and kindness in helping us to keep this distant observatory in good working. It is a very great pity that no telegraphic communication exists with Mergui; and unless one is very fortunate in hitting off a steamer, a reply to a communication cannot usually be got for some weeks.

Port Blair.—This observatory was inspected by Mr. Belcham towards the end of March last, when he found from examination of the clerk's records that the working of the self-registering tide-gauge was very satisfactory indeed until the 20th December; but that since the 21st December, when during a violent storm the waves broke through the observatory floor and splashed over the instrument causing the clock to stop and throwing the float-band off the stud-wheel, there had been no fewer than 16 stoppages of the clock causing interruptions in the record of from 4 to 10 hours. The clock was immediately taken down, cleaned, and set up again by the native mechanic; but its record is, notwithstanding, by no means a good one, for during the next four months there were

no fewer than 16 stoppages of about the same duration as before: it is, however, satisfactory to see that there has been no recurrence of it during the last 2 months. The gale of the 21st December appears to have damaged one of the two chronometers in the observatory by which the gauge clock is checked, and it was sent by the Port Officer to Calcutta for repairs, the other chronometer being substituted for it. Not satisfied with the clerk's method of checking the tide-gauge clock, he having nothing later than January in his time-book regarding the errors of the chronometers, Mr. Belcham took them both over to the S. S. *Peshwa* for comparison with the ship's chronometer: one of the two was then set to correct local time, and on returning to the observatory and comparing the gauge-clock with it, the clock was found to be fast no less than 7m. 17s. by local time. As it is impossible to trace the date from which the gauge-clock showed sensibly incorrect time, it has been thought best to put forward all the hour lines on the diagrams by this quantity between the 21st December and 21st March. Mr. Belcham further noticed considerable retardation, and found it to be due to the fact that the ingress and egress holes, which had been left in the masonry wall built round the iron cylinder since the previous inspection, had become choked, and the only means by which water found its way into the cylinder was by *percolation* from the bottom. Other holes were then pierced and fitted with zinc tubes of small diameter, and so far as the clerk's daily reports go, no retardation is since observable: I regret, however, that these reports cannot always be trusted as *bonâ fide* records of actual *observation*, for the daily reports up to the date of the inspection by Mr. Belcham gave no evidence whatever of retardation, although it was then present to the extent of over a foot in height and an hour in time!

The records of the self-registering aneroid and anemometer, and the working of the mercurial barometer, have been most satisfactory throughout the year, there being practically no breaks in the diagrams of the two former instruments.

Reduction of the Tidal Observations.

The amount of work done under this head during the year now reported on is greater than that of any previous year. Every endeavour was made to clear off as much of the arrears as possible; and the result is that the observations at 17 stations have been reduced, two years' calculations having been made in the case of 5 of them: the total out-turn is thus equal to 22 years' observations at one station. The tabulated values of the tidal constants so obtained are appended; but I regret that pressure of business in other directions has not left time to enter on any discussion of the yearly results referred to at page xvi of the Appendix to the Annual Report for 1887-88.

Nothing whatever has been heard during the year from Mr. Roberts, of the Nautical Almanac Office, regarding the tidal curves which he was asked to construct from the tentative reduction of the meteorological observations taken at Kárwár during three years, and their application to the ordinary tidal curves. Whenever the results are forthcoming, and if they are such as to justify the extension of the plan of reduction to other ports, I am strongly of opinion that the work should be confined to certain representative open-coast ports where the meteorological registrations after examination appear reliable enough to warrant the time and expense of calculation.

There has not been much extra-departmental work called for during the year. The demand of the Marine Survey for average errors in times and heights at two of the east coast stations was duly met and its utility acknowledged. A call for data regarding tides in Bombay, in connection with the special enquiries last May by Mr. Latham, regarding the drainage and sewage system of that town, was also met and the value of the information supplied is testified to in that officer's report. The engineer of the northern division also applied for the times and heights of high and low-water at Colaba in 1866 and 1877, but no data of the kind was available. This shows that the tidal registrations are becoming more and more appreciated.

The usual succinct annual reports of the work of this party in Bombay and Burma have also been furnished to their respective local governments.

The usual table showing the present stage of the tidal computations is appended. The letters A. P. found therein indicate that the *actual* times and heights of high and low-water for 1889 were measured in duplicate from the tidal diagrams and compared with the *predicted* values for that year.

State of the ordinary reductions of the yearly tidal-registrations at the beginning and end of the Survey year 1889-90.

Tidal observatory.	State at end of September 1889.	State at end of September 1890.
ADEN . . .	1887-88. Calculations completed. 1888-89. Diagrams not read off. A. P.	1888-89. Calculations completed. 1889-90. Diagrams read off. A. P.
KURRACHEE . .	1887-88. Diagrams read off, the hourly readings being copied from S. Series into the other series. 1888-89. Diagrams not read off. A. P.	1887-88. Calculations completed. 1888-89. Calculations completed. 1889-90. Diagrams read off. A. P.
BHÁVNAGAR . .	1888. Calculations completed. 1889. Diagrams not read off. A. P.	1889. Calculations completed. A. P.
BOMBAY (Apollo Bunder).	1887. Calculations completed. 1888. Calculations completed. 1889. Diagrams not read off. A. P.	1889. Calculations completed. A. P.
BOMBAY (Prince's Dock)	Newly started observatory. 1888-89. Diagrams read off, the hourly readings being copied from S. Series into the other series.	1888-89. Calculations completed. 1889. Calculations completed. A. P.
MORMUGAON (closed March 1889).	1887-88. Calculations completed. 1888-89. Calculations completed. A. P.	A. P.
COCHIN . . .	1888-89. Calculations completed. A. P.	1889-90. Calculations completed. A. P.
COLOMBO (closed 29th March 1890).	1887-88. Calculations completed. 1888-89. Diagrams not read off. A. P.	1888-89. Calculations completed. 1889-90. Calculations completed. A. P.
GALLE (closed 11th April 1890).	1887-88. Calculations completed. 1888-89. Diagrams not read off. A. P.	1888-89. Calculations completed. 1889-90. Calculations completed. A. P.
TUTICORIN . . .	1888-89. Calculations completed.	1889-90. Calculations completed.
MADRAS . . .	1886-87. Calculations completed. 1887-88. Calculations completed. 1888-89. Diagrams not read off. A. P.	1888-89. Calculations completed. A. P.
COCANADA . . .	1888-89. Calculations completed. A. P.	1889-90. Calculations completed. A. P.
KIDDERPORE . .	1886-87. Calculations completed. 1887-88. Calculations completed. 1888-89. Duplicates of S. Series read off from diagrams. A. P.	1888-89. Calculations completed. A. P.
CHITTAGONG . .	1888-89. Calculations completed. A. P.	1889-90. Calculations completed. A. P.
AKYAB . . .	1888-89. Calculations completed. A. P.	1889-90. Calculations completed. A. P.
RANGOON . . .	1886-87. Calculations completed. 1887-88. Calculations completed. 1888-89. Duplicates of S. Series read off from diagrams. A. P.	1888-89. Calculations completed. A. P.
MERGUI . . .	Newly started observatory. No diagrams read off.	1889-90. Caloulations completed.
PORT BLAIR . .	1887-88. Calculations completed. 1888-89. Diagrams not read off. A. P.	1888-89. Calculations completed. 1889-90. Calculations completed. A. P.

Values of the Tidal Constants, Aden, 1888-89.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1888-89 observations at Aden; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tides evaluated from the 1888-89 observations:—

Short Period Tides.

$A_0 = 5{\cdot}857$ feet.

S_1	H = R =	·090	M_6	R =	·007	Q_1	R =	·150		R =	·088
	κ = ζ =	173°·82		ζ =	2°·86		ζ =	57°·18	T_2	ζ =	329°·01
S_2	H = R =	·706		H =	·006		H =	·162		H =	·088
	κ = ζ =	244°·89		κ =	326°·07		κ =	32°·10		κ =	268°·47
S_4	H = R =	·004	M_8	R =	·002	L_2	R =	·045		R =	·017
	κ = ζ =	311°·50		ζ =	208°·07		ζ =	183°·60	$(MS)_4$	ζ =	274°·59
S_6	H = R =	·006		H =	·002		H =	·045		H =	·017
	κ = ζ =	194°·28		κ =	39°·02		κ =	232°·68		κ =	142°·32
S_8	H = R =	·001	O_1	R =	·613	N_2	R =	·460		R =	·018
	κ = ζ =	50°·19		ζ =	48°·11		ζ =	6°·84	$(2SM)_2$	ζ =	342°·87
				H =	·660		H =	4·52		H =	·018
				κ =	36°·74		κ =	220°·86		κ =	115°·14
M_1	R =	·053	K_1	R =	1·250	λ_2	R =	...		R =	·091
	ζ =	129°·58		ζ =	151°·41		ζ =	...	$2N_2$	ζ =	337°·97
	H =	·035		H =	1·306		H =	...		H =	·089
	κ =	357°·75		π =	34°·62		κ =	...		κ =	178°·28
M_2	R =	1·608	K_2	R =	·171	ν_2	R =	·161		R =	·045
	ζ =	357°·80		ζ =	291°·46		ζ =	121°·03	$(M_2N)_4$	ζ =	259°·72
	H =	1·579		H =	·194		H =	·158		H =	·043
	κ =	225°·54		κ =	238°·38		κ =	232°·09		κ =	341°·48
M_3	R =	·022	P_1	R =	·401	μ_2	R =	·077		R =	·026
	ζ =	227°·51		ζ =	283°·95		ζ =	98°·51	$(M_2K_1)_3$	ζ =	296°·86
	H =	·021		H =	·401		H =	·075		H =	·027
	κ =	209°·11		κ =	32°·39		κ =	193°·98		κ =	47°·81
M_4	R =	·004	J_1	R =	·097	R_2	R =	...		R =	·007
	ζ =	214°·08		ζ =	175°·96		ζ =	...	$(2M_2K_1)_3$	ζ =	160°·75
	H =	·004		H =	·102		H =	...		H =	·007
	κ =	309° 55		κ =	68°·78		κ =	...		κ =	13°·02

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·058	358°·27	·055	11°·99
„ Fortnightly „	·039	308·53	·046	19·01
Luni-Solar „ „	·010	318·55	·010	90·82
Solar-Annual „	·296	15·97	·296	357·53
„ Semi-Annual „	·116	167·03	·116	130·16

Values of the Tidal Constants, Kurrachee, 1887-88.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1887-88 observations at Kurrachee; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1887-88 observations:—

Short Period Tides.

$A_0 = 7{\cdot}152$ feet.

S_1	H = R =	·085	M_6	R =	·052	Q_1	R =	·133		R =	·117
	κ = ζ =	177°·18		ζ =	99°·00		ζ =	147°·56	T_2	ζ =	115°·83
S_2	H = R =	·964		H =	·048		H =	·151		H =	·117
	κ = ζ =	322°·98		κ =	203°·11		κ =	42°·07		κ =	357°·93
S_4	H = R =	·009	M_8	R =	·007	L_2	R =	·071		R =	·038
	κ = ζ =	38°·66		ζ =	330°·38		ζ =	351°·92	$(MS)_4$	ζ =	187°·73
S_6	H = R =	006		H =	·006		H =	·086		H =	·037
	κ = ζ =	308°·81		κ =	229°·19		κ =	284°·30		κ =	342°·43

Short Period Tides—contd.

A_0=7·152 feet.

S_8	H = R =	·000	O_1	R =	·590	N_2	R =	·634	$(2SM)_2$	R =	·016
	κ = ζ =	75°·96		ζ =	189°·42		ζ =	85°·60		ζ =	239°·77
				H =	·671		H =	·618		H =	·016
				κ =	45°·90		κ =	278°·34		κ =	85°·07
M_1	R =	·054	K_1	R =	1·210	λ_2	R =	...	$2N_2$	R =	·110
	ζ =	20°·82		ζ =	104°·57		ζ =	...		ζ =	14°·01
	H =	·031		H =	1·307		H =	...		H =	·108
	κ =	12°·93		κ =	46°·44		κ =	...		κ =	244°·78
M_2	R =	2·655	K_2	R =	·244	ν_2	R =	·031	$(M_2N)_4$	R =	·070
	ζ =	139°·07		ζ =	255°·60		ζ =	309°·13		ζ =	74°·45
	H =	2·586		H =	·297		H =	·030		H =	·067
	κ =	293°·77		κ =	320°·13		κ =	222°·02		κ =	61°·89
M_3	R =	·055	P_1	R =	·377	μ_2	R =	·074	$(M_2K_1)_3$	R =	061
	ζ =	274°·78		ζ =	355°·84		ζ =	322°·39		ζ =	359°·71
	H =	·053		H =	·377		H =	·070		H =	·065
	κ =	326°·84		κ =	46°·92		κ =	271°·80		κ =	96°·28
M_4	R =	·034	J_1	R =	·091	R_2	R =	...	$(2M_2K_1)_3$	R =	·005
	ζ =	48°·76		ζ =	163°·71		ζ =	...		ζ =	74°·75
	H =	·032		H =	·101		H =	...		H =	·005
	κ =	358°·17		κ =	63°·90		κ =	...		κ =	82°·29

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·077	142°·84	·071	104°·80
„ Fortnightly „	·038	37·19	·050	298·93
Luni-Solar „ „	·051	206·54	·050	51·84
Solar-Annual „	·092	347·94	·092	26·86
„ Semi-Annual „	·198	95·59	·198	173·42

Values of the Tidal Constants, Kurrachee, 1888-89.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1888-89 observations at Kurrachee; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1888-89 observations:—

Short Period Tides.

A_0=7·133 feet.

S_1	H = R =	·079	M_6	R =	·048	Q_1	R =	·115	T_2	R =	·133
	κ = ζ =	180°·15		ζ =	229°·34		ζ =	176°·26		ζ =	70°·69
S_2	H = R =	·966		H =	·046		H =	·122		H =	·133
	κ = ζ =	323°·07		κ =	201°·31		κ =	46°·16		κ =	312°·06
S_4	H = R =	·011	M_8	R =	·002	L_2	R =	·088	$(MS)_4$	R =	·041
	κ = ζ =	22°·74		ζ =	2°·86		ζ =	208°·37		ζ =	90°·15
S_6	H = R =	·007		H =	·002		H =	·084		H =	·040
	κ = ζ =	288°·69		κ =	205·49		κ =	310°·71		κ =	320°·80
S_8	H = R =	·001	O_1	R =	·624	N_2	R =	·608	$(2SM)_2$	R =	·020
	κ = ζ =	104°·04		ζ =	112°·35		ζ =	112°·42		ζ =	352°·66
				H =	·663		H =	·598		H =	·020
				κ =	46°·01		κ =	279°·32		κ =	122°·00
M_1	R =	·011	K_1	R =	1·250	λ_2	R =	...	$2N_2$	R =	·067
	ζ =	193°·79		ζ =	105°·31		ζ =	...		ζ =	125°·40
	H =	·008		H =	1·298		H =	...		H =	·066
	κ =	68°·57		κ =	46°·45		κ =	...		κ =	228°·54
M_2	R =	2·601	K_2	R =	·265	ν_2	R =	·117	$(M_2N)_4$	R =	·071
	ζ =	63°·82		ζ =	253°·88		ζ =	172°·50		ζ =	26°·87
	H =	2·559		H =	·296		H =	·115		H =	·069
	κ =	294°·48		κ =	316°·59		κ =	339°·50		κ =	64°·42
M_3	R =	·051	P_1	R =	·387	μ_2	R =	·047	$(M_2K_1)_3$	R =	·007
	ζ =	337°·21		ζ =	356°·88		ζ =	176°·27		ζ =	279°·73
	H =	·050		H =	·387		H =	·045		H =	·008
	κ =	323°·20		κ =	47°·22		κ =	277°·58		κ =	91°·52

Short Period Tides—contd.

A_1=7·133 feet.

M_4 R	= ·034	J_1 R	= ·076	R_2 R	= ...	$(2M_2K_1)_3$ R	= ·011
M_4 ζ	= 248°·13	J_1 ζ	= 91°·59	R_2 ζ	= ...	$(2M_2K_1)_3$ ζ	= 247°·09
M_4 H	= ·033	J_1 H	= ·079	R_2 H	= ...	$(2M_2K_1)_3$ H	= ·011
M_4 κ	= 349°·45	J_1 κ	= 92°·35	R_2 κ	= ...	$(2M_2K_1)_3$ κ	= 47°·26

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·015	157°·96	·014	221°·71
„ Fortnightly „	·007	248·94	·008	72·28
Luni-Solar „ „	·012	186·92	·012	316·26
Solar-Annual „	·090	19·31	·090	58·97
Semi-Annual „	·169	47·62	·169	126·95

VALUES OF THE TIDAL CONSTANTS, BHAVNAGAR, 1889.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889 observations at Bhavnagar; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889 observations.

Short Period Tides.

A_0=22·703 feet.

S_1 H = R	= ·105	M_6 R	= ·246	Q_1 R	= ·207	T_2 R	= ·420
S_1 κ = ζ	= 197°·30	M_6 ζ	= 60°·50	Q_1 ζ	= 266°·81	T_2 ζ	= 139°·16
S_2 H = R	= 3·469	M_6 H	= 240·	Q_1 H	= ·210	T_2 H	= ·420
S_2 κ = ζ	= 174°·40	M_6 κ	= 112°·65	Q_1 κ	= 81°·60	T_2 κ	= 139°·07
S_4 H = R	= ·116	M_8 R	= ·035	L_2 R	= ·546	$(MS)_4$ R	= ·644
S_4 κ = ζ	= 240°·36	M_8 ζ	= 251°·03	L_2 ζ	= 282°·33	$(MS)_4$ ζ	= 175°·77
S_6 H = R	= ·016	M_8 H	= ·034	L_2 H	= ·453	$(MS)_4$ H	= ·638
S_6 κ = ζ	= 318°·25	M_8 κ	= 60°·56	L_2 κ	= 138°·59	$(MS)_4$ κ	= 193°·16
S_8 H = R	= ·004	O_1 R	= ·984	N_2 R	= 2·375	$(2SM)_2$ R	= ·100
S_8 κ = ζ	= 7°·70	O_1 ζ	= 243°·80	N_2 ζ	= 120°·81	$(2SM)_2$ ζ	= 357°·51
		O_1 H	= 1·000	N_2 H	= 2·356	$(2SM)_2$ H	= ·099
		O_1 κ	= 83°·08	N_2 κ	= 113°·71	$(2SM)_2$ κ	= 340°·12
M_1 R	= ·063	K_1 R	= 2·265	λ_2 R	= ...	$2N_2$ R	= ·472
M_1 ζ	= 357°·34	K_1 ζ	= 267°·26	λ_2 ζ	= ...	$2N_2$ ζ	= 88°·24
M_1 H	= ·059	K_1 H	= 2·288	λ_2 H	= ...	$2N_2$ H	= ·468
M_1 κ	= 158°·66	K_1 κ	= 89°·50	λ_2 κ	= ...	$2N_2$ κ	= 56°·65
M_2 R	= 10·809	K_2 R	= ·817	ν_2 R	= ·340	$(M_2N)_4$ R	= ·386
M_2 ζ	= 115°·80	K_2 ζ	= 341°·18	ν_2 ζ	= 26°·80	$(M_2N)_4$ ζ	= 57°·69
M_2 H	= 10·723	K_2 H	= ·855	ν_2 H	= ·337	$(M_2N)_4$ H	= ·380
M_2 κ	= 133°·19	K_2 κ	= 165°·77	ν_2 κ	= 88°·14	$(M_2N)_4$ κ	= 67°·97
M_3 R	= ·093	P_1 R	= ·674	μ_2 R	= ·293	$(M_2K_1)_3$ R	= ·077
M_3 ζ	= 294°·27	P_1 ζ	= 282°·86	μ_2 ζ	= 243°·32	$(M_2K_1)_3$ ζ	= 308°·40
M_3 H	= ·092	P_1 H	= ·674	μ_2 H	= ·288	$(M_2K_1)_3$ H	= ·077
M_3 κ	= 320°·35	P_1 κ	= 91°·73	μ_2 κ	= 278°·09	$(M_2K_1)_3$ κ	= 148°·03
M_4 R	= ·856	J_1 R	= ·260	R_2 R	= ...	$(2M_2K_1)_3$ R	= ·159
M_4 ζ	= 111°·36	J_1 ζ	= 318°·90	R_2 ζ	= ...	$(2M_2K_1)_3$ ζ	= 146°·71
M_4 H	= ·842	J_1 H	= ·262	R_2 H	= ...	$(2M_2K_1)_3$ H	= ·158
M_4 κ	= 146°·13	J_1 κ	= 161°·49	R_2 κ	= ...	$(2M_2K_1)_3$ κ	= 359°·24

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·068	318°·87	·066	343°·36
„ Fortnightly „	·063	169·31	·066	328·13
Luni-Solar „ „	·106	63·19	·105	45·81
Solar-Annual „	·178	183·69	·178	104·82
„ Semi-Annual „	·112	329·81	·112	172·06

VALUES OF THE TIDAL CONSTANTS, BOMBAY (APOLLO BUNDER), 1889.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889 observations at Bombay (Apollo Bunder); and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889 observations:—

Short Period Tides.

$A_0 = 10{\cdot}209$ feet.

S_1	H = R	·065	M_6	R =	·006	Q_1	R =	·144	T_2	R =	·199
	$\kappa = \zeta$	195°·38		ζ =	55°·18		ζ =	229°·51		ζ =	344°·88
S_2	H = R	1·631		H =	·006		H =	·147		H =	·199
	$\kappa = \zeta$	3°·01		κ =	107°·48		κ =	44°·37		κ =	344°·79
S_4	H = R	·003	M_8	R =	·003	L_2	R =	·092	$(MS)_4$	R =	·161
	$\kappa = \zeta$	209°·54		ζ =	275°·19		ζ =	107°·01		ζ =	16°·16
S_6	H = R	·001		H =	·003		H =	·076		H =	·159
	$\kappa = \zeta$	120°·26		κ =	344°·93		κ =	323°·30		κ =	33°·59
S_8	H = R	·002	O_1	R =	·656	N_2	R =	1·018	$(2SM)_2$	R =	·047
	$\kappa = \zeta$	222°·51		ζ =	209°·66		ζ =	323°·38		ζ =	108°·40
				H =	·668		H =	1·010		H =	·047
				κ =	48°·99		κ =	316°·35		κ =	90°·96
M_1	R =	·051	K_1	R =	1·384	λ_2	R =	...	$2N_2$	R =	·122
	ζ =	193°·24		ζ =	223°·13		ζ =	...		ζ =	277°·37
	H =	·047		H =	1·398		H =	...		H =	·121
	κ =	354°·58		κ =	45°·38		κ =	...		κ =	245°·87
M_2	R =	4·072	K_2	R =	·389	ν_2	R =	·041	$(M_2N)_4$	R =	·149
	ζ =	313°·56		ζ =	163°·46		ζ =	184°·43		ζ =	246°·52
	H =	4·040		H =	·407		H =	·040		H =	·147
	κ =	331°·00		κ =	348°·04		κ =	245°·85		κ =	256°·73
M_3	R =	·056	P_1	R =	·416	μ_2	R =	·205	$(M_2K_1)_3$	R =	·088
	ζ =	350°·24		ζ =	236°·13		ζ =	257°·61		ζ =	283°·29
	H =	·055		H =	·416		H =	·201		H =	·089
	κ =	16°·39		κ =	45°·00		κ =	292°·47		κ =	122°·97
M_4	R =	·145	J_1	R =	·117	R_2	R =	...	$(2M_2K_1)_3$	R =	·054
	ζ =	302°·61		ζ =	248°·36		ζ =	...		ζ =	240°·61
	H =	·143		H =	·118		H =	...		H =	·054
	κ =	337°·48		κ =	90°·93		κ =	...		κ =	93°·23

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·069	202·32	·067	226·78
„ Fortnightly „	·036	189·45	·038	348·22
Luni-Solar „ „	·037	205·72	·037	188·29
Solar-Annual „	·072	64·97	·072	346·10
„ Semi-Annual „	·105	339·25	·105	181·50

VALUES OF THE TIDAL CONSTANTS, BOMBAY (PRINCE'S DOCK), 1888-89.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1888-89 observations at Bombay (Prince's Dock); and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1888-89 observations.

Short Period Tides.

$A_0 = 8{\cdot}267$ feet.

S_1	H = R	·052	M_6	R =	·002	Q_1	R =	·131	T_2	R =	...
	$\kappa = \zeta$	153°·39		ζ =	195°·52		ζ =	356°·88		ζ =	...
S_2	H = R	1·656		H =	·002		H =	·135		H =	...
	$\kappa = \zeta$	1°·23		κ =	2°·43		κ =	154°·95		κ =	...
S_4	H = R	·015	M_8	R =	·006	L_2	R =	·130	$(MS)_4$	R =	·159
	$\kappa = \zeta$	204°·70		ζ =	334°·44		ζ =	20°·25		ζ =	94°·34
S_6	H = R	·005		H =	006		H =	·113		H =	·158
	$\kappa = \zeta$	279°·09		κ =	76° 98		κ =	284°·75		κ =	29°·97

Short Period Tides—contd.

A_0=8·207 feet.

S_8	H = R =	·002	O_1	R =	·640	N_2	R =	1·025	$(2SM)_2$	R =	·045
	κ = ζ =	142°·71		ζ =	192°·30		ζ =	173°·94		ζ =	9°·91
				H =	·662		H =	1·013		H =	·044
				κ =	48°·34		κ =	311°·61		κ =	74°·27
M_1	R =	·028	K_1	R =	1·358	λ_2	R =	...	$2N_2$	R =	·200
	ζ =	189°·88		ζ =	320°·37		ζ =	...		ζ =	279°·25
	H =	·023		H =	1·387		H =	...		H =	·198
	κ =	113°·89		κ =	44°·14		κ =	...		κ =	258°·96
M_2	R =	4·142	K_2	R =	·382	ν_2	R =	·351	$(M_2N)_4$	R =	·092
	ζ =	32°·98		ζ =	14°·19		ζ =	290°·56		ζ =	344°·85
	H =	4·095		H =	·410		H =	·347		H =	·090
	κ =	328°·62		κ =	1°·96		κ =	321°·83		κ =	58°·16
M_3	R =	·083	P_1	R =	·379	μ_2	R =	·250	$(M_2K_1)_3$	R =	·109
	ζ =	308°·98		ζ =	135°·51		ζ =	76°·52		ζ =	132°·82
	H =	·082		H =	·379		H =	·245		H =	·110
	κ =	32°·44		κ =	42°·95		κ =	307°·79		κ =	152°·22
M_4	R =	·131	J_1	R =	·068	R_2	R =	...	$(2M_2K_1)_3$	R =	·048
	ζ =	98°·67		ζ =	207°·79		ζ =	...		ζ =	275°·38
	H =	·128		H =	·069		H =	...		H =	·048
	κ =	329°·94		κ =	85°·54		κ =	...		κ =	62°·89

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·026	139°·71	·025	297°·68
„ Fortnightly „	·045	300·66	·049	344·23
Luni-Solar „ „	·020	52·60	·020	116·96
Solar-Annual „	·076	101·05	·076	283·61
„ Semi-Annual „	·130	128·78	·130	133·91

Values of the Tidal Constants, Bombay (Prince's Dock), 1889.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889 observations at Bombay (Prince's Dock); and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889 observations:—

Short Period Tides.

A_0=8·246 feet.

S_1	H = R =	·067	M_6	R =	·006	Q_1	R =	·147		R =	·173
	κ = ζ =	189°·72		ζ =	109°·89		ζ =	227°·51	T_2	ζ =	320°·02
S_2	H = R =	1·644		H =	·006		H =	·150		H =	·173
	κ = ζ =	0°·99		κ =	162°·18		κ =	42°·37		κ =	319°·93
S_4	H = R =	·013	M_8	R =	·005	L_2	R =	·082		R =	·155
	κ = ζ =	209°·91		ζ =	326°·31		ζ =	75°·21	$(MS)_4$	ζ =	14°·56
S_6	H = R =	·007		H =	·005		H =	·068		H =	·154
	κ = ζ =	301°·76		κ =	36°·04		κ =	291°·50		κ =	31°·99
S_8	H = R =	·002	O_1	R =	·668	N_2	R =	1·012		R =	·037
	κ = ζ =	189°·46		ζ =	208°·85		ζ =	320°·40	$(2SM)_2$	ζ =	59°·14
				H =	·680		H =	1·004		H =	·037
				κ =	48°·18		κ =	313°·37		κ =	41°·71
M^1	H =	·056	K_1	R =	1·376	λ_2	R =	...	$2N_2$	R =	·143
	ζ =	180°·83		ζ =	222°·40		ζ =	...		ζ =	275°·52
	H =	·052		H =	1·390		H =	...		H =	·142
	κ =	342°·17		κ =	44°·65		κ =	...		κ =	244°·02

Short Period Tides—contd.

A_1=8·240 feet.

M_2	H =	4·148	K_2	R =	·402	ν_2	R =	·098	$(M_2N)_4$	R =	·139
	ζ =	312°·00		ζ =	168°·91		ζ =	218°·98		ζ =	248°·40
	H =	4·115		H =	·421		H =	·097		H =	·137
	κ =	329°·44		κ =	353°·50		κ =	280°·40		κ =	258°·80
M_3	H =	·068	P_1	R =	·410	μ_2	R =	·207	$(M_2K_1)_3$	R =	·086
	ζ =	358°·00		ζ =	234°·50		ζ =	268°·94		ζ =	297°·24
	H =	·067		H =	·410		H =	·204		H =	·086
	κ =	24°·15		κ =	43°·37		κ =	303°·80		κ =	136°·92
M_4	H =	·128	J_1	R =	·122	R_2	R =	...	$(2M_2K_1)_3$	R =	·052
	ζ =	295°·68		ζ =	254°·87		ζ =	...		ζ =	226°·61
	H =	·126		H =	·123		H =	...		H =	·052
	κ =	330°·55		κ =	97°·44		κ =	...		κ =	79°·23

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·065	205°·26	·063	229°·72
„ Fortnightly „	·050	186·92	·052	345·69
Luni-Solar „ „	·020	176·94	·020	159·51
Solar-Annual „	·091	49·05	·091	330·18
„ Semi-Annual „	·122	335·64	·122	177·90

Values of the Tidal Constants, Cochin, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Cochin; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

A_0=2·421 feet.

S_1	H = R =	·028	M_6	R =	·011	Q_1	R =	·084	T_2	R =	·025
	κ = ζ =	179°·39		ζ =	345°·43		ζ =	92°·46		ζ =	108°·22
S_2	H = R =	·256		H =	011		H =	·085		H =	·025
	κ = ζ =	26°·87		κ =	82°·92		κ =	65°·31		κ =	84°·48
S_4	H = R =	·005	M_8	R =	·002	L_2	R =	·036	$(MS)_4$	R =	·017
	κ = ζ =	173°·29		ζ =	88°·24		ζ =	32°·83		ζ =	346°·64
S_6	H = R =	·005		H =	·002		H =	·029		H =	·017
	κ = ζ =	211°·37		κ =	338°·23		κ =	339°·58		κ =	139°·14
S_8	H = R =	·002	O_1	R =	·304	N_2	R =	·155	$(2SM)_2$	R =	·003
	κ = ζ =	210°·47		ζ =	108°·56		ζ =	130°·83		ζ =	117°·35
				H =	·308		H =	·154		H =	·003
				κ =	59°·31		κ =	305°·43		κ =	324°·85
M_1	R =	·035	K_1	R =	·587	λ_2	R =	...	$2N_2$	R =	·031
	ζ =	146°·86		ζ =	205°·72		ζ =	...		ζ =	48°·59
	H =	·033		H =	·591		H =	...		H =	·031
	κ =	20°·37		κ =	51°·60		κ =	...		κ =	245°·29
M_2	R =	·735	K_2	R =	·075	ν_2	R =	·029	$(M_2N)_4$	R =	·014
	ζ =	179°·29		ζ =	150°·73		ζ =	330°·75		ζ =	108°·97
	H =	·730		H =	·078		H =	·029		H =	·014
	κ =	331°·79		κ =	22°·55		κ =	255°·74		κ =	76°·07
M_3	R =	·008	P_1	R =	·165	μ_2	R =	·007	$(M_2K_1)_3$	R =	·035
	ζ =	347°·47		ζ =	265°·47		ζ =	231°·20		ζ =	118°·80
	H =	·008		H =	·165		H =	·007		H =	·035
	κ =	216°·22		κ =	50°·69		κ =	176°·20		κ =	117°·17
M_4	R =	·025	J_1	R =	·052	R_2	R =	...	$(2M_2K_1)_3$	R =	·015
	ζ =	126°·19		ζ =	262°·15		ζ =	....		ζ =	359°·84
	H =	·024		H =	·052		H =	...		H =	·015
	κ =	71°·18		κ =	81°·80		κ =	...		κ =	98°·96

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·059	208°·06	·058	185°·96
„ Fortnightly „	·040	272·45	·041	343·46
Luni-Solar „ „	·025	45·37	·025	252·88
Solar-Annual „	·363	348·54	·363	293·32
„ Semi-Annual „	·072	278·17	·072	167·72

Values of the Tidal Constants, Galle, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Galle ; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

A_0 = 2·570 feet

S_1	H = R =	·012	M_6	R =	·002	Q_1	R =	·023	T_2	R =	·039
	κ = ζ =	63°·02		ζ =	261°·47		ζ =	159°·80		ζ =	161°·94
S_2	H = R =	·358		H =	·002		H =	·024		H =	·039
	κ = ζ =	93° 51		κ =	270°·57		κ =	104°·02		κ =	72°·91
S_4	H = R =	·004	M_8	R =	·001	L_2	R =	·024	$(MS)_4$	R =	·007
	κ = ζ =	213°·28		ζ =	343°·30		ζ =	353°·23		ζ =	15°·83
S_6	H = R =	001		H =	·001		H =	·024		H =	·007
	κ = ζ =	296°·57		κ =	235° 43		κ =	75°·28		κ =	258°·86
S_8	H = R =	·003	O_1	R =	·046	N_2	R =	·074	$(2SM)_2$	R =	·009
	κ = ζ =	322°·70		ζ =	95°·41		ζ =	194°·67		ζ =	247°·58
				H =	·049		H =	·072		H =	·009
				κ =	70°·95		κ =	46°·38		κ =	4°·55
M_1	R =	·010	K_1	R =	1·60	λ_2	R =	...	$2N_2$	R =	·004
	ζ =	124°·80		ζ =	106°·22		ζ =	..		ζ =	351°·03
	H =	·007		H =	·166		H =	.		H =	·004
	κ =	3°·06		κ =	17°·83		κ =	...		κ =	171°·42
M_2	R =	·536	K_2	R =	·087	ν_2	R =	·029	$(M_2N)_4$	R =	·017
	ζ =	172°·73		ζ =	85°·25		ζ =	283°·10		ζ =	86°·90
	H =	·527		H =	·098		H =	·028		H =	·017
	κ =	55° 76		κ =	88°·95		κ =	82°·39		κ =	181°·64
M_3	R =	·014	P_1	R =	·053	μ_2	R =	·025	$(M_2K_1)_3$	R =	·002
	ζ =	154°·59		ζ =	299°·92		ζ =	336°·83		ζ =	215°·84
	H =	·013		H =	·053		H =	·024		H =	·002
	κ =	159°·14		κ =	19°·87		κ =	102°·90		κ =	10°·48
M_4	R =	·016	J_1	R =	·007	R_2	R =	...	$(2M_2K_1)_3$	R =	·006
	ζ =	36°·25		ζ =	119°·06		ζ =	...		ζ =	156°·93
	H =	·015		H =	·008		H =	...		H =	·006
	κ =	162°·32		κ =	57°·87		κ =	...		κ =	11°·38

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·037	350°·74	·035	22°·06
„ Fortnightly „	·026	303·18	·030	55·13
Luni-Solar „ „	·013	290·43	·013	47·40
Solar-Annual „	·324	294·74	·324	304·80
„ Semi-Annual „	·178	64·52	·178	84·63

Values of the Tidal Constants, Galle, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Galle; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

$A_0 = 2{\cdot}685$ feet.

S_1	H = R =	·011	M_6	R =	·002	Q_1	R =	·025	T_2	R =	·024
	κ = ζ =	13°·64		ζ =	80°·54		ζ =	147°·44		ζ =	128°·20
S_2	H = R =	·361		H =	·002		H =	·025		H =	·024
	κ = ζ =	96°·40		κ =	31°·23		κ =	104°·13		κ =	39°·43
S_4	H = R =	·003	M_8	R =	·002	L_2	R =	·024	$(MS)_4$	R =	·005
	κ = ζ =	248°·96		ζ =	97°·13		ζ =	111°·18		ζ =	259°·59
S_6	H = R =	·000		H =	·002		H =	·020		H =	·005
	κ = ζ =	206°·57		κ =	31°·38		κ =	32°·98		κ =	243°·16
S_8	H = R =	·001	O_1	R =	·041	N_2	R =	·072	$(2SM)_2$	R =	·012
	κ = ζ =	261°·87		ζ =	355°·47		ζ =	190°·17		ζ =	351°·10
				H =	·041		H =	·071		H =	·012
				κ =	72°·20		κ =	53°·69		κ =	7°·54
M_1	R =	·003	K_1	R =	·166	λ_2	R =	...	$2N_2$	R =	·004
	ζ =	261°·12		ζ =	108°·70		ζ =	...		ζ =	305°·89
	H =	·003		H =	·166		H =	...		H =	·009
	κ =	64°·08		κ =	19°·61		κ =	...		κ =	49°·31
M_2	R =	·534	K_2	R =	·106	ν_2	R =	·030	$(M_2N)_4$	R =	·016
	ζ =	75°·36		ζ =	92°·91		ζ =	317°·17		ζ =	51°·69
	H =	·531		H =	·108		H =	·030		H =	·016
	κ =	58°·93		κ =	94°·72		κ =	46°·46		κ =	258°·78
M_3	R =	·011	P_1	R =	·046	μ_2	R =	·021	$(M_2K_1)_3$	R =	·002
	ζ =	198°·97		ζ =	203°·73		ζ =	120°·69		ζ =	111°·25
	H =	·010		H =	·046		H =	·021		H =	·002
	κ =	174°·32		κ =	23°·91		κ =	87°·81		κ =	5°·73
M_4	R =	·012	J_1	R =	·010	R_2	R =	...	$(2M_2K_1)_3$	R =	·007
	ζ =	192°·31		ζ =	355°·24		ζ =	...		ζ =	279°·32
	H =	·012		H =	·010		H =	...		H =	·007
	κ =	159°·44		κ =	22°·11		κ =	...		κ =	335°·54

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·039	282°·12	038	42°·16
„ Fortnightly „	·012	7°·86	·012	17°·96
Luni-Solar „	·020	197°·39	·020	213°·83
Solar-Annual „	·392	286°·78	·392	296°·59
„ Semi-Annual „	·159	116°·22	·159	135°·85

Values of the Tidal Constants, Colombo, 1888-89.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1888-89 observations at Colombo; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1888-89 observations:—

Short Period Tides.

$A_0 = 2{\cdot}112$ feet.

S_1	H = R =	·004	M_6	R =	·004	Q^1	R =	·033	T_2	R =	·033
	κ = ζ =	62°·85		ζ =	287°·45		ζ =	0°·88		ζ =	107°·83
S_2	H = R =	·392		H =	·004		H =	·035		H =	·033
	κ = ζ =	94°·11		κ =	5°·30		κ =	90°·82		κ =	77°·94
S_4	H = R =	·005	M_8	R =	·001	L_2	R =	0·34	$(MS)_4$	R =	·011
	κ = ζ =	247°·38		ζ =	243°·44		ζ =	13°·58		ζ =	337°·99
S_6	H = R =	·002		H =	·001		H =	·035		H =	·010
	κ = ζ =	195°·95		κ =	227°·24		κ =	54°·67		κ =	243°·94

Short Period Tides—contd.

A_0=2·112 feet.

S_8	H = R =	·000	O_1	R =	·090	N_2	R =	·087	$(2SM)_2$	R =	·007
	κ = ζ =	291°·80		ζ =	3°·38		ζ =	94°·89		ζ =	240°·26
				H =	·098		H =	0·85		H =	·007
				κ =	60°·76		κ =	33°·40		κ =	334°·31
M_1	R =	·023	K_1	R =	·229	λ_2	R =	...	$2N_2$	R =	·008
	ζ =	103°·00		ζ =	180°·83		ζ =	...		ζ =	11°·17
	H =	·015		H =	·240		H =	...		H =	·008
	κ =	347°·82		κ =	33°·48		κ =	...		κ =	342°·25
M_2	R =	·607	K_2	R =	·111	ν	R =	·022	$(M_2N)_4$	R =	·028
	ζ =	145°·19		ζ =	207°·27		ζ =	24°·095		ζ =	76°·74
	H =	·596		H =	·127		H =	·021		H =	·027
	κ =	51°·14		κ =	93°·12		κ =	22°·13		κ =	181°·20
M_3	R =	·012	P_1	R =	·071	μ_2	R =	·020	$(M_2K_1)_3$	R =	·010
	ζ =	131°·55		ζ =	257°·57		ζ =	296°·43		ζ =	21°·80
	H =	·012		H =	·071		H =	·019		H =	·010
	κ =	170°·48		κ =	36°·65		κ =	108°·33		κ =	140°·40
M_4	R =	·018	J_1	R =	·016	R_2	R =	...	$(2M_2K_1)_3$	R =	·005
	ζ =	356°·03		ζ =	234°·46		ζ =	...		ζ =	36°·39
	H =	·017		H =	·017		H =	...		H =	·500
	κ =	167°·93		κ =	50°·47		κ =	...		κ =	355°·63

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·052	49°·03	·051	16°·47
,, Fortnightly ,, ...	·013	93·88	·015	65·08
Luni-Solar ,, ,, ...	·010	107·72	·010	261·77
Solar-Annual ,, ...	·276	352·78	·276	303·70
,, Semi-Annual ,, ...	·190	186·69	·190	88·52

Values of the Tidal Constants, Colombo, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Colombo; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations.

Short Period Tides.

A_0 = 2·216 feet.

S_1	H = R =	·016	M_6	R =	·004	Q_1	R =	·031	T_2	R =	·047
	κ = ζ =	61·63		ζ =	81°·63		ζ =	35°·25		ζ =	57°·86
S_2	H = R =	·394		H =	·004		H =	·031		H =	·047
	κ = ζ =	94°·34		κ =	27°·83		κ =	99°·45		κ =	27°·24
S_4	H = R =	·005	M_8	R =	·001	L_2	R =	·020	$(MS)_4$	R =	·012
	κ = ζ =	265°·60		ζ =	159°·44		ζ =	190°·18		ζ =	269°·49
S_6	H = R =	·002		H =	·001		H =	·016		H =	·012
	κ = ζ =	170°·13		κ =	87°·71		κ =	57°·11		κ =	251°·55
S_8	H = R =	·001	O_1	R =	·090	N_2	R =	·090	$(2SM)_2$	R =	·014
	κ = ζ =	172°·03		ζ =	284°·83		ζ =	118°·60		ζ =	347°·47
				H =	·091		H =	·090		H =	·014
				κ =	58°·25		κ =	31°·44		κ =	5°·41
M_1	R =	·014	K_1	R =	·237	λ_2	R =	...	$2N_2$	R =	·008
	ζ =	191°·23		ζ =	179°·01		ζ =	...		ζ =	235°·69
	H =	·0·4		H =	·238		H =	...		H =	·008
	κ =	340°·92		κ =	31°·77		κ =	...		κ =	79°·30
M_2	R =	·590	K_2	R =	·102	ν_2	R =	·017	$(M_2N)_4$	R =	·038
	ζ =	66°·32		ζ =	195°·80		ζ =	335°·61		ζ =	25°·28
	H =	·586		H =	·105		H =	·017		H =	·037
	κ =	48°·40		κ =	81°·39		κ =	11°·07		κ =	280°·19

Short Period Tides—contd.

A^0=2·216 feet.

M_3	R =	·016	P_1	R =	·081	μ_3	R =	·014	$(M_2K_1)_3$	R =	·001
	ζ =	208°·52		ζ =	238°·78		ζ =	118°·81		ζ =	339°·44
	H =	·016		H =	·081		H =	·014		H =	·001
	κ =	181°·62		κ =	17°·12		κ =	82°·94		κ =	174°·28
M_4	R =	·018	J_1	R =	·008	R_2	R =	...	$(2M_2K_1)_3$	R =	·005
	ζ =	200°·01		ζ =	127°·17		ζ =	...		ζ =	203°·36
	H =	·018		H =	·008		H =	...		H =	·005
	κ =	164°·14		κ =	45°·03		κ =	...		κ =	314°·72

Long Period Tides.

	R	ζ.	R	κ
Lunar Monthly Tide	·027	357°·83	·026	67°·06
„ Fortnightly „	·029	49·10	·030	304·32
Luni-Solar „ „	·016	259·88	·016	277·82
Solar-Annual „	·353	344·59	·353	296·17
„ Semi-Annual „	·165	226·68	·165	130·01

Values of the Tidal Constants, Tuticorin, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Tuticorin; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889 90 observations:—

Short Period Tides.

A_0= 2·186 feet

S_1	H = R =	·043	M_6	R =	·016	Q_1	R =	·042	T_2	R =	·021
	κ = ζ =	58°·39		ζ =	287°·43		ζ =	333°·89		ζ =	195°·68
S_2	H = R =	·466		H =	·016		H =	·042		H =	·021
	κ = ζ =	84°·20		κ =	22°·70		κ =	66°·77		κ =	45°·80
S_4	H = R =	·005	M_8	R =	·002	L_2	R =	·029	$(MS)_4$	R =	·011
	κ = ζ =	238°·63		ζ =	257°·47		ζ =	98°·96		ζ =	339°·12
S_6	H = R =	·007		H =	·002		H =	·023		H =	·011
	κ = ζ =	176°·68		κ =	264°·50		κ =	41°·93		κ =	250°·88
S_8	H = R =	·015	O_1	R =	·129	N_2	R =	·080	$(2SM)_2$	R =	·004
	κ = ζ =	230°·60		ζ =	100°·85		ζ =	330°·82		ζ =	270°·80
				H =	·127		H =	·080		H =	·004
				κ =	44°·58		κ =	32°·43		κ =	359°·04
M_1	R =	·017	K_1	R =	·295	λ_2	R =	...	$2N_2$	R =	·003
	ζ =	271°·70		ζ =	55°·66		ζ =	...		ζ =	88°·15
	H =	·017		H =	·294		H =	...		H =	·003
	κ =	52°·68		κ =	27°·72		κ =	...		κ =	299°·61
M_2	R =	·660	K_2	R =	·135	ν_2	R =	·027	$(M_2N)_4$	R =	·022
	ζ =	132°·57		ζ =	317°·53		ζ =	27°·82		ζ =	74°·21
	H =	·658		H =	·135		H =	·027		H =	·022
	κ =	44°·32		κ =	81°·55		κ =	63°·61		κ =	47°·58
M_3	R =	·022	P_1	R =	·072	μ_2	R =	·021	$(M_2K_1)_3$	R =	·007
	ζ =	294°·18		ζ =	362°·75		ζ =	271°·62		ζ =	256°·40
	H =	·022		H =	·072		H =	·021		H =	·007
	κ =	161°·82		κ =	11°·81		κ =	95°·14		κ =	140°·22
M_4	R =	·035	J_1	R =	·010	R_2	R =	...	$(2M_2K_1)_3$	R =	·008
	ζ =	330°·80		ζ =	201°·39		ζ =	...		ζ =	111°·25
	H =	·024		H =	·000		H =	...		H =	·008
	κ =	154°·32		κ =	19°·57		κ =	...		κ =	322°·71

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·048	224°·55	·048	74°·70
„ Fortnightly „	·030	124·08	·029	328·37
Luni-Solar „	·012	205·72	·012	293·96
Solar-Annual „	·348	226·64	·348	297·57
„ Semi-Annual „	·093	329·98	·093	111·84

VALUES OF THE TIDAL CONSTANTS, MADRAS, 1888-89.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1888-89 observations at Madras; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1888-89 observations:—

Short Period Tides.

A_0 = 2·133 feet.

S_1	H = R =	·023	M_6	R =	·008	Q_1	R =	·010	T_2	R =	·017
	κ = ζ =	95°·04		ζ =	149°·17		ζ =	340°·63		ζ =	140°·37
S_2	H = R =	·461		H =	·008		H =	·010		H =	·017
	κ = ζ =	278°·36		κ =	164°·00		κ =	147°·00		κ =	56°·27
S_4	H = R =	·002	M_8	R =	·001	L_2	R =	·044	$(MS)_4$	R =	·007
	κ = ζ =	236°·98		ζ =	343°·30		ζ =	175°·01		ζ =	234°·78
S_6	H = R =	·001		H =	·001		H =	·044		H =	·006
	κ = ζ =	135°·00		κ =	3°·08		κ =	313°·63		κ =	239°·73
S_8	H = R =	·004	O_1	R =	·091	N_2	R =	·272	$(2SM)_2$	R =	·022
	κ = ζ =	304°·99		ζ =	224°·33		ζ =	200°·27		ζ =	251°·65
				H =	·098		H =	·268		H =	·021
				κ =	326°·70		κ =	239°·22		κ =	246°·71
M_1	R =	·028	K_1	R =	·289	λ_2	R =	...	$2N_2$	R =	·063
	ζ =	27°·29		ζ =	74°·56		ζ =	...		ζ =	127°·37
	H =	·019		H =	·301		H =	...		H =	·062
	κ =	326°·07		κ =	341°·26		κ =	...		κ =	200°·32
M_2	R =	1·081	K_2	R =	·117	ν_2	R =	·074	$(M_2N)_4$	R =	·023
	ζ =	245°·18		ζ =	286°·97		ζ =	289°·90		ζ =	208°·42
	H =	1·063		H =	·132		H =	·073		H =	·022
	κ =	250°·13		κ =	280°·84		κ =	267°·68		κ =	252°·32
M_3	R =	·006	P_1	R =	·098	μ_2	R =	·052	$(M_2K_1)_3$	R =	·014
	ζ =	201°·25		ζ =	260°·41		ζ =	178°·10		ζ =	150°·05
	H =	·006		H =	·098		H =	·050		H =	·014
	κ =	28°·67		κ =	345°·29		κ =	187°·99		κ =	61°·69
M_4	R =	·010	J_1	R =	·028	R	R =	...	$(2M_2K_1)_3$	R =	·006
	ζ =	202°·89		ζ =	110°·46		ζ =	...		ζ =	297°·41
	H =	·010		H =	·029		H =	...		H =	·006
	κ =	212°·78		κ =	339°·03		κ =	...		κ =	40°·60

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·064	15°·28	·060	341°·27
„ Fortnightly „	·048	48·30	·056	28·52
Luni-Solar „ „	·045	337·64	·044	332·69
Solar-Annual „	·397	218·73	·397	223·85
„ Semi-Annual „	·391	103·20	·391	113·46

Values of the Tidal Constants, Cocanada, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Cocanada; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

$A_0 = 5{\cdot}413$ feet.

S_1	H = R =	·034	M_6	R =	·016	Q_1	R =	·002	T_2	R =	·053
	κ = ζ =	61°·55		ζ =	68°·63		ζ =	97°·77		ζ =	296°·17
S_2	H = R =	·632		H =	·016		H =	·002		H =	·053
	κ = ζ =	287°·58		κ =	92°·89		κ =	93°·11		κ =	208°·39
S_4	H = R =	·006	M_8	R =	·003	L_2	R =	·075	$(MS)_4$	R =	·023
	κ = ζ =	143°·70		ζ =	238°·57		ζ =	299°·27		ζ =	133°·70
S_6	H = R =	·001		H =	·003		H =	·061		H =	·023
	κ = ζ =	146°·31		κ =	270°·92		κ =	232°·42		κ =	141°·79
S_8	H = R =	·002	O_1	R =	·144	N_2	R =	·327	$(2SM)_2$	R =	·015
	κ = ζ =	114°·23		ζ =	231°·56		ζ =	344°·20		ζ =	175°·60
				H =	·144		H =	·325		H =	·014
				κ =	332°·81		κ =	245° 38		κ =	167°·51
M_1	R =	·022	K_1	R =	·346	λ_2	R =	...	$2N_2$	R =	·073
	ζ =	247°·48		ζ =	69°·64		ζ =	...		ζ =	88°·09
	H =	·022		H =	·346		H =	...		H =	·072
	κ =	62°·48		κ =	339°·56		κ =	...		κ =	242°·37
M_2	R =	1·500	K_2	R =	·157	ν_2	R =	·116	$(M_2N)_4$	R =	·046
	ζ =	245°·32		ζ =	290°·47		ζ =	127°·31		ζ =	217°·11
	H =	1·493		H =	·161		H =	·115		H =	·045
	κ =	253°·41		κ =	290°·30		κ =	252°·51		κ =	126°·38
M_3	R =	·007	P_1	R =	·096	μ_2	R =	·029	$(M_2K_1)_3$	R =	·013
	ζ =	16°·19		ζ =	262° 91		ζ =	244°·95		ζ =	288°·58
	H =	·007		H =	·096		H =	·029		H =	·013
	κ =	28°·32		κ +	344°·09		κ =	261°·12		κ =	206°·59
M_4	R =	·031	J_1	R =	·019	R_2	R =	...	$(2M_2K_1)_3$	R =	·012
	ζ =	90°·78		ζ =	316°·30		ζ =	...		ζ =	220°·91
	H =	·030		H =	·019		H =	...		H =	·012
	κ =	106°·96		κ =	329°·05		κ =	...		κ =	327°·16

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·067	231°·86	·066	338°·77
„ Fortnightly „ . . .	·088	352·76	·089	336·35
Luni-Solar „ . . .	·059	2·86	·059	354·78
Solar-Annual „ . . .	·731	204·02	·731	212·85
„ Semi-Annual „ . . .	·394	101·48	·394	119·13

Values of the Tidal Constants, Kidderpore, 1888-89.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1888-89 observations at Kidderpore; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1888-89 observations:—

Short Period Tides.

$A_0 = 10{\cdot}842$ feet.

S_1	H = R =	·091	M_6	R =	·171	Q_1	R =	·024	T_2	R =	·176
	κ = ζ =	201°·49		ζ =	301°·12		ζ =	27°·20		ζ =	246°·18
S_2	H = R =	1·496		H =	·163		H =	·026		H =	·176
	κ = ζ =	100°·17		κ =	323°·33		κ =	356°·58		κ =	167°·03
S_4	H = R =	·094	M_8	R =	·055	L_1	R =	·154	$(MS)_4$	R =	·694
	κ = ζ =	109°·94		ζ =	121° 55		ζ =	219°·97		ζ =	313°·75
S_6	H = R =	·001		H =	·080		H =	·152		H =	·682
	κ = ζ =	339°·44		κ =	271°·16		κ =	55°·41		κ =	81°·15

Short Period Tides—contd.

A_0=10·842 feet.

S_8	H = R =	·001	O_1	R =	·199	N_2	R =	·750	$(2SM)_2$	R =	·072
	κ = ζ =	212°·47		ζ =	154°·41		ζ =	172°·81		ζ =	153°·04
M_1	R =	·042		H =	·213		H =	·737		H =	·071
	ζ =	33°·20		κ =	24°·16		κ =	39°·83		κ =	25°·64
	H =	·028	K_1	R =	·389	λ_2	R =	…	$2N_2$	R =	·092
	κ =	32°·78		ζ =	151°·57		ζ =	…		ζ =	55°·52
M_2	R =	3·784		H =	·406		H =	…		H =	·090
	ζ =	290°·67		κ =	53°·33		κ =	…		κ =	22°·17
	H =	3·720	K_2	R =	·365	ν_2	R =	·261	$(M_2N)_4$	R =	·071
	κ =	58°·07		ζ =	106°·04		ζ =	259°·71		ζ =	250°·84
M_3	R =	·047		H =	·411		H =	·256		H =	·068
	ζ =	274·53		κ =	90°·05		κ =	56°·79		κ =	245°·27
	H =	·046	P_1	R =	·120	μ_2	R =	·201	$(M_2K_1)_3$	R =	·096
	κ =	285°·64		ζ =	310°·37		ζ =	291°·53		ζ =	20°·26
M_4	R =	·806		H =	·120		H =	·194		H =	·099
	ζ =	142°·98		κ =	40°·19		κ =	186°·34		κ =	49°·42
	H =	·779	J_1	R =	·041	R_2	R =	…	$(2M_2K_1)_3$	R =	·032
	κ =	37°·78		ζ =	233°·07		ζ =	…		ζ =	299°·47
				H =	044		H =	…		H =	·032
				κ =	31°·10		κ =	…		κ =	292°·51

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·333	104°·90	·314	5°·28
„ Fortnightly „	·208	189·60	·243	37·49
Luni-Solar „ „	·917	168·90	·901	41·49
Solar-Annual „	2·810	153·35	2·810	153·53
„ Semi-Annual „	1·289	352·19	1·289	332·55

Values of the Tidal Constants, Chittagong, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Chittagong; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

A_0 = 8·086 feet.

S_1	H = R =	·077	M_6	R =	·141	Q_1	R =	·020	T_2	R =	·074
	κ = ζ =	105°·21		ζ =	17°·32		ζ =	54°·00		ζ =	237°·29
S_2	H = R =	1·584		H =	·140		H =	·019		H =	·074
	κ = ζ =	70°·86		κ =	182°·79		κ =	355°·91		κ =	83°·50
S_4	H = R =	·061	M_8	R =	·027	L_2	R =	·224	$(MS)_4$	R =	·346
	κ = ζ =	64°·95		ζ =	139°·67		ζ =	167°·64		ζ =	211°·55
S_6	H = R =	007		H =	·027		H =	·181		H =	·345
	κ = ζ =	159°·25		κ =	120°·31		κ =	65°·96		κ =	26°·71
S_3	H = R =	·004	O_1	R =	·292	N_2	R =	·825	$(2SM)_2$	R =	·124
	κ = ζ =	146°·31		ζ =	165°·78		ζ =	115°·52		ζ =	110°·98
M_1	R =	·044		H =	·289		H =	·823		H =	·823
	ζ =	13°·18		κ =	9°·00		κ =	28°·77		κ =	295°·83
	H =	·043	K_1	R =	600	λ_2	R =	…	$2N_2$	R =	·335
	κ =	106°·76		ζ =	46°·98		ζ =	…		ζ =	19°·57
M_2	R =	4·497		H =	·596		H =	…		H =	·334
	ζ =	219°·45		κ =	22°·95		κ =	…		κ =	30°·90
	H =	4·485	K_2	R =	·470	ν_2	R =	·315	$(M_2N)_4$	R =	·056
	κ =	34°·61		ζ =	293°·86		ζ =	155°·92		ζ =	115°·42
				H =	·471		H =	·314		H =	·056
				κ =	65°·69		κ =	50°·28		κ =	203°·82

Short Period Tides—contd.

A_0=8·086 feet.

M_3	R =	·031	P_1	R =	·185	μ_2	R =	·303	$(M_2K_1)_3$	R =	·095
	ζ =	94°·14		ζ =	19°·03		ζ =	213°·48		ζ =	137°·94
	H =	·031		H =	·185		H =	·301		H =	·094
	κ =	176°·88		κ =	34°·19		κ =	203°·80		κ =	289°·07
M_4	R =	·393	J_1	R =	·039	R_2	R =	...	$(2M_2K_1)_3$	R =	·072
	ζ =	351°·57		ζ =	160°·06		ζ =	...		ζ =	251°·88
	H =	·391		H =	·038		H =	...		H =	·071
	κ =	341°·89		κ =	33°·91		κ =	...		κ =	266°·22

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·228	98°·27	·226	0°·18
„ Fortnightly „	·030	72·65	·029	21·36
Luni-Solar „ „	·355	214·05	·354	38·90
Solar-Annual „	1·221	61 03	1·221	135·87
„ Semi-Annual „	·120	351·80	·120	141·47

VALUES OF THE TIDAL CONSTANTS, AKYAB, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Akyab; and also the *mean* values of the amplitudes (H) and of the epoch (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

A_0 = 7·684 feet.

S_1	H = R =	·048	M_6	R =	·021	Q_1	R =	·011	T_2	R =	·088
	κ = ζ =	71°·79		ζ =	62°·34		ζ =	5°·66		ζ =	100°·04
S_2	H = R =	1·126		H =	·021		H =	·011		H =	·088
	κ = ζ =	307°·03		κ =	116°·11		κ =	303°·24		κ =	333°·84
S_4	H = R =	·011	M_8	R =	·006	L_2	R =	·095	$(MS)_4$	R =	·008
	κ = ζ =	201°·00		ζ =	330°·40		ζ =	75°·91		ζ =	122°·87
S_6	H = R =	·002		H =	·006		H =	0·77		H =	·008
	κ = ζ =	123°·69		κ =	162°·09		κ =	289°·82		κ =	260°·79
S_8	H = R =	·002	O_1	R =	·188	N_2	R =	·526	$(2SM)_2$	R =	·030
	κ = ζ =	46°·85		ζ =	142°·08		ζ =	27°·69		ζ =	354°·29
				H =	·186		H =	·524		H =	·030
				κ =	335°·71		κ =	269°·57		κ =	216°·37
M_1	R =	·023	K_1	R =	·444	λ_2	R =	...	$2N_2$	R =	·105
	ζ =	309°·52		ζ =	34°·93		ζ =	...		ζ =	278°·71
	H =	·023		H =	·442		H =	...		H =	·105
	κ =	18°·16		κ =	343°·28		κ =	...		κ =	264°·53
M_2	R =	2·568	K_2	R =	·331	ν_2	R =	·172	$(M_2N)_4$	R =	·051
	ζ =	139°·65		ζ =	232°·20		ζ =	127°·17		ζ =	81°·35
	H =	2·559		H =	·335		H =	·171		H =	·051
	κ =	277°·58		κ =	308°·83		κ =	301°·20		κ =	101°·15
M_3	R =	·015	P_1	R =	·130	μ_2	R =	·028	$(M_2K_1)_3$	R =	·045
	ζ =	0°·78		ζ =	300°·89		ζ =	354°·45		ζ =	343°·48
	H =	·015		H =	·130		H =	·028		H =	·044
	κ =	27°·67		κ =	343°·65		κ =	270°·30		κ =	69°·75
M_4	R =	·004	J_1	R =	·038	R_2	R =	...	$(2M_2K_1)_3$	R =	·017
	ζ =	312°·61		ζ =	125°·97		ζ =	...		ζ =	99°·46
	H =	·004		H =	·038		H =	...		H =	·017
	κ =	228°·46		κ =	326°·32		κ =	...		κ =	66°·96

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·027	104°·69	·027	0°·74
„ Fortnightly „	·029	124·79	·029	55·46
Luni-Solar „ „	·036	202·99	·036	65·07
Solar-Annual „	·768	111·79	·768	159·02
„ Semi-Annual „	·234	46·47	·234	140·94

VALUES OF THE TIDAL CONSTANTS, RANGOON, 1888-89.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1888-89 observations at Rangoon; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1888-89 observations :—

Short Period Tides.

$A_0 = 10{\cdot}385$ feet.

S_1	H = R =	·114	M_6	R =	·206	Q_1	R =	·010	T_2	R =	·380
	κ = ζ =	132°·30		ζ =	331°·34		ζ =	12°·14		ζ =	208°·67
S_2	H = R =	2·070		H =	·196		H =	·010		H =	·380
	κ = ζ =	172°·62		κ =	91°·25		κ =	69°·38		κ =	150°·23
S_4	H = R =	·086	M_8	R =	·096	L_2	R =	·514	$(MS)_4$	R =	4·08
	κ = ζ =	262°·17		ζ =	52°·77		ζ =	72°·32		ζ =	298°·27
S_6	H = R =	·008		H =	·090		H =	·517		H =	·400
	κ = ζ =	25°·59		κ =	92°·65		κ =	145°·64		κ =	218°·24
S_8	H = R =	·002	O_1	R =	·345	N_2	R =	1·155	$(2MS)_2$	R =	·187
	κ = ζ =	254°·48		ζ =	348°·42		ζ =	182°·70		ζ =	333°·08
				H =	·264		H =	1·135		H =	·184
				κ =	31°·39		κ =	146°·94		κ =	53°·11
M_1	R =	·053	K_1	R =	·647	λ_2	R =	...	$2N_2$	R =	·262
	ζ =	170°·91		ζ =	154°·59		ζ =	...		ζ =	100°·26
	H =	·035		H =	·676		H =	...		H =	·257
	κ =	65°·03		κ =	35°·69		κ =	...		κ =	48°·77
M_2	R =	5·976	K_2	R =	·556	ν_2	R =	·519	$(M_2N)_4$	R =	·074
	ζ =	213°·48		ζ =	229°·97		ζ =	293°·16		ζ =	161°·67
	H =	5·870		H =	·630		H =	·510		H =	·072
	κ =	133°·45		κ =	172°·68		κ =	120°·70		κ =	15°·88
M_3	R =	·048	P_1	R =	·161	μ_2	R =	·545	$(M_2K_1)_3$	R =	·082
	ζ =	268°·39		ζ =	305°·40		ζ =	92°·00		ζ =	258°·42
	H =	·046		H =	·161		H =	·526		H =	·084
	κ =	328°·35		κ =	55°·90		κ =	291°·94		κ =	59°·49
M_4	R =	·479	J_1	R =	·042	R_2	R =	...	$(2M_2K_1)_3$	R =	·108
	ζ =	334°·36		ζ =	215°·89		ζ =	...		ζ =	105°·83
	H =	·462		H =	·045		H =	...		H =	·109
	κ =	174°·30		κ =	78°·62		κ =	...		κ =	64°·67

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·222	24°·94	·209	10°·67
„ Fortnightly „	·163	359·10	·192	13·14
Luni-Solar „ „	·497	323·17	·488	43·20
Solar-Annual „	1·258	164·37	1·258	143·83
Semi-Annual „	·206	4·83	·206	323·75

Values of the Tidal Constants, Mergui, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Mergui; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

$A_0 = 13{\cdot}084$ feet.

S_1	H = R =	·083	M_6	R =	·071	Q_1	R =	·031	T_2	R =	...
	$\kappa = \zeta =$	73°·14		$\zeta =$	178°·39		$\zeta =$	252°·91		$\zeta =$	...
S_2	H = R =	2·903		H =	·070		H =	·031		H =	...
	$\kappa = \zeta =$	349°·79		$\kappa =$	217°·41		$\kappa =$	274°·33		$\kappa =$	...
S_4	H = R =	·042	M_8	R =	·023	L_2	R =	·252	$(MS)_4$	R =	·168
	$\kappa = \zeta =$	226°·84		$\zeta =$	127°·64		$\zeta =$	254°·56		$\zeta =$	280°·88
S_6	H = R =	·022		H =	·023		H =	·205		H =	·167
	$\kappa = \zeta =$	108°·68		$\kappa =$	59°·67		$\kappa =$	300°·94		$\kappa =$	173°·88
S_8	H = R =	·003	O_1	R =	·210	N_2	R =	1·074	$(2SM)_2$	R =	·177
	$\kappa = \zeta =$	236°·31		$\zeta =$	320°·59		$\zeta =$	29°·22		$\zeta =$	31°·60
				H =	·211		H =	1·068		H =	·176
				$\kappa =$	317°·67		$\kappa =$	306°·57		$\kappa =$	138°·60
M_1	R =	·028	K_1	R =	·524	λ_2	R =	...	$2N_2$	R =	·197
	$\zeta =$	85°·52		$\zeta =$	73°·45		$\zeta =$	...		$\zeta =$	323°·72
	H =	·028		H =	·524		H =	...		H =	1·96
	$\kappa =$	20°·78		$\kappa =$	333°·48		$\kappa =$	...		$\kappa =$	265°·41
M_2	R =	5·536	K_2	R =	·773	ν_2	R =	·329	$(M_2N)_4$	R =	·118
	$\zeta =$	56°·78		$\zeta =$	4°·71		$\zeta =$	170°·74		$\zeta =$	14°·16
	H =	5·506		H =	·792		H =	·327		H =	·117
	$\kappa =$	309°·78		$\kappa =$	344°·76		$\kappa =$	294°·53		$\kappa =$	184°·51
M_3	R =	·040	P_1	R =	·150	μ_2	R =	·442	$(M_3K_1)_3$	R =	·079
	$\zeta =$	112°·60		$\zeta =$	243°·86		$\zeta =$	201°·35		$\zeta =$	339°·60
	H =	·040		H =	·150		H =	·437		H =	·078
	$\kappa =$	132°·11		$\kappa =$	334°·94		$\kappa =$	347°·36		$\kappa =$	132°·63
M_4	R =	·122	J_1	R =	·046	R_2	R =	...	$(2M_2K_1)_3$	R =	·012
	$\zeta =$	342°·89		$\zeta =$	112°·24		$\zeta =$	...		$\zeta =$	90°·15
	H =	·120		H =	·046		H =	...		H =	·011
	$\kappa =$	128°·91		$\kappa =$	343°·83		$\kappa =$	...		$\kappa =$	336°·15

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·035	55°·83	·034	31°·50
„ Fortnightly „ . . .	·043	271°·84	·043	350·69
Luni-Solar „ „ . . .	·055	252·73	·055	0·72
Solar-Annual „ . . .	·492	168·64	·492	167·56
„ Semi-Annual „ . . .	·220	111·44	·220	109·29

Values of the Tidal Constants, Port Blair, 1888-89.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1888-89 observations at Port Blair; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1888-89 observations:—

Short Period Tides.

$A_0 = 4{\cdot}625$ feet.

S_1	H = R =	·018	M_6	R =	·002	Q_1	R =	·017	T_2	R =	·099
	$\kappa = \zeta =$	45°·00		$\zeta =$	3°·01		$\zeta =$	270°·34		$\zeta =$	75°·30
S_2	H = R =	·961		H =	·002		H =	·018		H =	·099
	$\kappa = \zeta =$	313°·84		$\kappa =$	318°·00		$\kappa =$	244°·16		$\kappa =$	328°·56

Short Period Tides—contd.

A_0=4·625 feet.

S_4	H = R =	·004	M_8	R =	·001	L_2	R =	·067	$(MS)_4$	R =	·007
	κ = ζ =	79°·46		ζ =	74°·06		ζ =	14°·12		ζ =	147°·60
S_6	H = R =	·001		H =	·001		H =	·065		H =	·006
	κ = ζ =	51°·34		κ =	14°·04		κ =	252°·96		κ =	312°·60
S_8	H = R =	·001	O_1	R =	·145	N_2	R =	4·20	$(2SM)_2$	R =	·018
	κ = ζ =	100°·31		ζ =	62°·48		ζ =	9°·60		ζ =	341°·26
				H =	·155		H =	·414		H =	·018
				κ =	302°·34		κ =	268°·56		κ =	176°·27
M_1	R =	·030	K_1	R =	·385	λ_2	R =	...	$2N_2$	R =	·078
	ζ =	315°·94		ζ =	37°·65		ζ =	...		ζ =	264°·98
	H =	·021		H =	·400		H =	...		H =	·076
	κ =	336°·77		κ =	326°·92		κ =	...		κ =	257°·91
M_2	R =	2·086	K_2	R =	·256	ν_2	R =	·080	$(M_2N)_4$	R =	·046
	ζ =	112°·56		ζ =	271°·64		ζ =	79°·17		ζ =	66°·17
	H =	2·052		H =	·287		H =	·079		H =	·045
	κ =	277°·55		κ =	310°·03		κ =	317°·12		κ =	130°·13
M_3	R =	·005	P_1	R =	·119	μ_2	R =	·089	$(M_2K_1)_3$	R =	·022
	ζ =	325°·31		ζ =	265°·88		ζ =	324°·64		ζ =	313°·88
	H =	·005		H =	·119		H =	·086		H =	·023
	κ =	32°·80		κ =	328°·12		κ =	294°·64		κ =	48°·15
M_4	R =	·008	J_1	R =	·035	R_2	R =	...	$2M_2K_1)_3$	R =	·007
	ζ =	167°·47		ζ =	126°·87		ζ =	...		ζ =	167°·07
	H =	·008		H =	·037		H =	...		H =	·007
	κ =	137°·46		κ =	318°·04		κ =	...		κ =	207°·80

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·028	114°·70	·027	20°·73
„ Fortnightly „	·032	141·29	·037	6·73
Luni-Solar „ „	·011	86·43	·011	281·43
Solar-Annual „	·183	98·03	·183	125·79
„ Semi-Annual „	·143	124·86	·143	180·36

Values of the Tidal Constants, Port Blair, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Port Blair; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

A_0=4·586 feet.

S_1	H = R =	·010	M_6	R =	·002	Q_1	R =	·021	T_2	R =	·093
	κ = ζ =	26°·06		ζ =	149°·74		ζ =	233°·19		ζ =	55°·33
S_2	H = R =	·924		H =	·002		H =	·021		H =	·093
	κ = ζ =	318°·57		κ =	226°·38		κ =	219°·41		κ =	308°·84
S_4	H = R =	·002	M_8	R =	·001	L_2	R =	·104	$(MS)_4$	R =	·008
	κ = ζ =	83°·66		ζ =	323°·13		ζ =	211°·56		ζ =	331°·02
S_6	H = R =	·001		H =	·001		H =	·084		H =	·008
	κ = ζ =	63°·44		κ =	305°·31		κ =	290°·87		κ =	236°·56
S_3	H = R =	·001	O_1	R =	·149	N_2	R =	·403	$(2S\ M)_2$	R =	·024
	κ = ζ =	111°·80		ζ =	323°·74		ζ =	7°·94		ζ =	46°·51
				H =	·149		H =	·401		H =	·024
				κ =	304°·72		κ =	278°·72		κ =	140°·97

Short Period Tides—contd.

A_0=4·586 feet.

M_1	R =	·006	K_1	R =	·388	λ_2	R =	...	$2N_2$	R =	·074
	ζ =	74°·48		ζ =	39°·99		ζ =	...		ζ =	329°·77
	H =	·006		H =	·387		H =	...		H =	·074
	κ =	22°·43		κ =	328°·62		κ =	...		κ =	245°·80
M_2	R =	1·926	K_2	R =	·279	ν_2	R =	·115	$(M_2 N)_4$	R =	·060
	ζ =	17°·62		ζ =	282°·24		ζ =	117°·76		ζ =	268°·21
	H =	1·917		H =	·284		H =	·114		H =	·060
	κ =	283°·16		κ =	319°·46		κ =	285°·73		κ =	84°·54
M_3	R =	·010	P_1	R =	·131	μ_2	R =	·069	$(M_2 K_1)_3$	R =	·020
	ζ =	344°·48		ζ =	264°·81		ζ =	136°·89		ζ =	331°·03
	H =	·009		H =	·131		H =	·069		H =	·020
	κ =	22°·79		κ =	327°·29		κ =	307°·98		κ =	165°·21
M_4	R =	·008	J_1	R =	·036	R_2	R =	...	$(2M_2 K_1)_3$	R =	·008
	ζ =	310°·76		ζ =	56°·14		ζ =	...		ζ =	332°·42
	H =	·008		H =	·036		H =	...		H =	·008
	κ =	121°·85		κ =	335°·45		κ =	...		κ =	214°·88

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·050	52°·07	·049	46°·83
„ Fortnightly „	·056	235·45	·056	359·02
Luni-Solar „ „	·025	313·44	·025	47·90
Solar-Annual „ „	·079	320·11	·079	347·63
„ Semi-Annual „	·016	162·51	·016	217·56

The Tide-Tables.

In addition to the calculations already mentioned, the usual work has been done in connection with the issue of tide-tables for 1890 (which were received *en bloc*, in the last week of December 1889, and distributed with the least possible delay), and with the preparation of those for 1891. The values of the constants have, as heretofore, been supplied to Mr. Roberts of the Nautical Almanac Office, ready for use in the predictor. No change has been made on former procedure in the mode of calculating these constants, as set forth in the annual report for 1884-85 for the open-coast stations and in prefaces in the tide-tables for the several riverain ports, except that in the predictions for 1889 and thereafter, only nineteen, instead of twenty, tidal constituents are utilized, the smaller evectional tide λ having been pronounced by Professor Darwin to be too insignificant to take cognizance of.

The prefaces for the tide-tables were carefully scrutinized and certain typographical errors, &c., in the printing of the tables for previous years, which were detected, were brought to Mr. Roberts' notice, in time to prevent their recurrence in the next issue of the tables. The volume of tide-tables for 1891 will contain the predictions for 31 ports, Mergui being the port now appearing therein for the first time. Moreover, in order to place Mr. Roberts as early as possible in a position to test the correctness of the results of the tide-predictor and enable him to make such corrections to its indications as a comparison of actual times and heights of high and low-water would appear to require, *before* sending to press the "copy" for the 1891 tide-tables, he has been furnished with a tabular statement for each working port, as well as for Moulmein (closed in 1886), giving the results of the comparisons for 1889. These comparisons have thus, this year for the first time, been all placed with Mr. Roberts sufficiently early to allow of their being utilized in the predictions for the coming year. The amount of work done in this way is indicated in the accompanying table, by the letters A. P.; these denote that the actual times and heights referred to were measured from the tidal diagrams in duplicate and compared with the values as predicted. In certain cases the differences found had a decided leaning in a particular direction which, on close examination, exonerated the tidal registrations; the inference seemed to show that a more or less constant correction was needed to the values brought out by the predictor.

The free distribution of the tide-tables for 1890 has been carried out in accordance with the lists lately sanctioned by Government. The amount realized by the sale of the

tables for 1890 has reached a higher figure than before ; as far as the accounts have been rendered, *to the end of September*, R1,094 have been so realized and carried into the accounts of the department; the total receipts from the 1889 tide-tables during the whole of that year was R1,050.

The final datum — Indian spring low-water mark — for the Mergui tidal observatory has been determined from a year's observations and found to be 9·144 feet below mean sea-level, and 3·940 feet above zero of gauge.

The usual tabular statements are appended, showing the percentage and amount of errors in the predicted times and heights of high and low-water at 15 ports for the year 1889, as determined by comparing the predicted values with those actually measured off the tidal diagrams, and also for Moulmein, where personal observations have been taken twice daily during daylight, expressly for these comparisons.

No. 1.

Statement showing the percentage and the amount of the Errors in the Predicted Times of High Water at the various Tidal Stations for the year 1889.

Stations.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes, and under.	Errors over 5 minutes, and under 15 minutes.	Errors over 15 minutes, and under 20 minutes.	Errors over 20 minutes, and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	687	34	38	13	10	5
Kurrachee	698	18	36	16	25	5
Bhávnagar	700	35	39	11	11	4
Bombay	703	38	44	12	4	2
Mormugáo	164	38	46	7	7	2
Cochin	698	33	34	12	13	8
Colombo	629	33	44	9	9	5
Galle	682	41	35	10	8	6
Madras	293	47	34	9	8	2
Cocanada	703	42	47	6	4	1
Kidderpore	706	24	38	13	18	7
Chittagong	693	20	34	16	21	9
Akyab	704	44	41	9	5	1
Rangoon	699	23	45	14	13	5
Moulmein	364	38	35	12	10	5
Port Blair	691	35	39	10	11	5

No. 2.

Statement showing the percentage and the amount of the Errors in the Predicted Times of Low Water at the various Tidal Stations for the year 1889.

Stations.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	691	33	41	12	10	4
Kurrachee	701	24	39	16	17	4
Bhávnagar	691	23	32	12	17	16
Bombay	703	29	43	11	11	6
Mormugáo	165	43	34	11	8	4
Cochin	697	42	36	8	9	5
Colombo	625	35	42	9	7	7
Galle	666	39	37	8	10	6
Madras	293	37	43	12	7	1
Cocanada	703	38	43	9	8	2
Kidderpore	704	27	38	13	15	7
Chittagong	691	16	27	14	20	23
Akyab	700	43	41	8	6	2
Rangoon	697	28	40	12	13	7
Moulmein	365	29	36	11	12	12
Port Blair	696	34	44	10	7	5

No. 3.

Statement showing the percentage and the amount of the Errors in the Predicted Heights of High Water at the various Tidal Stations for the year 1889.

Stations.	Number of comparisons between the actual and predicted values.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
		Per cent.	Per cent.	Per cent.	Per cent.
Aden	687	97	3	...	...
Kurrachee	698	89	10	1	...
Bhávnagar	700	33	26	17	24
Bombay	703	81	17	2	...
Mormugáo	163	93	7	...	...
Cochin	698	92	7	1	...
Colombo	629	90	10	...	...
Galle	682	88	12	...	...
Madras	293	86	13	1	...
Cocanada	703	73	22	5	...
Kidderpore	706	44	27	15	14
Chittagong	693	37	28	22	13
Akyab	704	69	22	7	2
Rangoon	699	64	29	6	1
Moulmein	364	40	23	15	22
Port Blair	691	81	19	...	...

No. 4.

Statement showing the percentage and the amount of the Errors in the Predicted Heights of Low Water at the various Tidal Stations for the year 1889.

Stations.	Number of comparisons between the actual and predicted values.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
		Per cent.	Per cent.	Per cent.	Per cent.
Aden	691	96	4	...	...
Kurrachee	701	73	24	3	...
Bhávnagar	691	16	18	17	49
Bombay	703	69	26	4	1
Mormugáo	165	75	25	...	...
Cochin	697	88	12	...	...
Colombo	625	88	12	...	...
Galle	666	88	12	...	...
Madras	293	86	13	1	...
Cocanada	703	62	27	10	1
Kidderpore	704	40	28	14	18
Chittagong	691	43	32	18	7
Akyab	700	70	25	4	1
Rangoon	697	41	29	16	14
Moulmein	365	32	16	13	39
Port Blair	696	82	18	...	...

These statements may be summarized as follows:—

Percentage of predictions within 15 minutes of the actuals.

	High water. Per cent.	Low water. Per cent.
11 Open Coast stations	76	76
5 Riverain stations	66	59

Percentage of predictions within 8 inches in height of the actuals.

	High water. Per cent.	Low water. Per cent.
11 Open Coast stations	98	96
5 Riverain stations	70	59

The above compare favorably with the similar statement given in the report for 1888-89: the only deteriorations being in the low-water height percentage of the riverain stations, which is readily accounted for by the personal observations at Moulmein differing more largely than before from the predictions.

A table showing the average errors in the predicted times, and in the heights of high and low-water expressed in terms of the range, at 16 ports, is subjoined, for the year 1889. It will be seen by comparing it with the similar statement of the previous year that Negapatam and Elephant Point do not now occur (those observatories having been closed in 1888), while Akyab appears here for the first time. Apart from trifling differ-

ences, it will be noticed that both Aden and Kurrachee show a sensible increase of average error in time, while Bhávnagar, Cochin, Colombo, Madras and Cocanada show a marked decrease: the cases of Aden and Kurrachee have been brought to Mr. Roberts' notice; and as regards the improvement in Madras, this is solely due to the keeping of only the good work at that port; nearly seven months' bad work being excluded from the results here tabulated. There is a sensibly marked decrease of average error in the heights of high and low water, excepting at Cochin, Moulmein and Port Blair: Mr. Roberts' attention has been called to the first of these, in case there may have been some error in the predictions; at Port Blair, however, the increase in error is due entirely to the choking-up of the communication holes in the cylinder, which a little proper supervision might have obviated; Moulmein calls for no remarks beyond those previously stated.

Table of Average Errors in the Predicted Times and Heights of High and Low water at the several Tidal Stations for the year 1889.

Stations.	Mean Range at Springs in feet.	Average Errors.					
		Of Time, in minutes.		Of Height, in terms of the Range.		Of Height, in inches.	
		H. W.	L. W.	H. W. Feet.	L. W. Feet.	H. W.	L. W.
Aden	6·7	12	11	·025	·025	2	2
Kurrachee	9·7	15	13	·017	·026	2	3
Bhávnagar	31·8	11	16	·021	·034	8	13
Bombay	14·5	9	12	·017	·017	3	3
Mormugáo	7·0	9	10	·024	·036	2	3
Cochin	3·2	13	10	·078	·078	3	3
Colombo	2·4	12	12	·069	·069	2	2
Galle	2·2	11	12	·076	·076	2	2
Madras	3·5	9	10	·048	·048	2	2
Cocanada	5·2	8	10	·048	·064	3	4
Kidderpore	11·7	14	13	·043	·050	6	7
Chittagong	13·5	16	20	·043	·037	7	6
Akyab	8·4	8	9	·040	·030	4	3
Rangoon	16·4	13	13	·020	·036	4	7
Moulmein	12·7	11	14	·052	·092	8	14
Port Blair	6·6	11	11	·038	·038	3	3

Levelling Operations.

The operations during the season under report include the following lines of double levelling:—

Section I.—From Hyderabad (Deccan) to Bezváda (in the Kistna district).

Section II.—From Navánár (near the head of the Gulf of Cutch) to a little north of Tatta in Sind.

Of these, the first section is in continuation of the line of levels that was carried down from Bidar to Hyderabad in 1888-89.

The work of the present season was begun at the Hyderabad Residency, where the heights of several permanent bench-marks had been fixed during the previous year, and followed the main road *viâ* Súrayapet and Nandigáma to Bezvada, a distance of 165 miles. In this portion 15 permanent bench-marks were embedded, and the heights of three principal stations of the Trigonometrical Survey finally determined by short branch lines specially run for the purpose: in addition, the heights of numerous mile-stones, &c., along the road have been obtained, the point of reference being in each case permanently cut on the spot where the levelling staff was placed. Thus, this section has determined the final heights of no fewer than 200 permanent points of reference, which, when published, can always be utilized hereafter as points for starting or checking road, canal, railway or other levels. A comparison of the value of the height of the terminus at Bezváda as now obtained with that derived from the operations of 1887-88 from Madras to Cocanada, shows that the present value is about 8 inches (0·64 feet) higher than that formerly obtained; and the difference has as usual been dispersed over the section under report. Another issue of the work on this line is the practicability which it affords of a second independent comparison of the closing difference (nearly 3 feet) at Madras, which was shown up by the direct levelling from Bombay *viâ* Gulbarga, Raichur, and Cuddapah (in 1880-81). Starting from Bombay and adopting the uncorrected values as furnished by the former lines as far as Gulbarga; then proceeding *viâ* Bidar, Hyderabad, and Bezváda to Madras, the value of a bench-mark at the latter place is found to be only 1·64 feet higher in terms of Bombay mean sea-level than if referred to the mean sea-level at Madras, a quantity which can easily be understood to accumulate over 900 miles of levelling, however carefully executed. The results of this section will be published as usual at the Trigonometrical Branch office, Dehra Dun, and the pamphlet will be known as No. 6, Madras Presidency and Nizam's Dominions.

The above line having been completed by the 24th December, the detachment at once started for the *locale* of the second section, and by the 10th January had reached their ground in Cutch. A few days' delay occurred at the start, searching for the bench-marks which had been put down at Navánár when the tidal work was inaugurated there in 1874-75,

and in making the necessary arrangements for a protracted land journey across Cutch, the Rann, and onwards. Two of the three bench-marks originally left at Navánár were non-existent, the encroachment of the sea having destroyed all trace of them and altered the configuration of the foreshore: the third was found, but as no confidence could obviously be placed in its having maintained its former level, the work emanating from it was connected with two others of the old bench-marks well inland at Mundra (9½ miles from Navánár); this showed that the present level of the bench-mark at Navánár is ⅞ths of an inch higher than before; and hence the originally embedded bench-mark at Mundra has been accepted as the origin of this section. The line followed the country road to Kera and the main road to Mánkuwa, a short branch line of 3½ miles having been run to Bhúj, where two substantial bench-marks were fixed in the Agency compound. The line then followed the cart track as far as Lakhpat. Considerable delay was experienced in getting to the right bank of the Khori Creek, and several attempts to carry the line at what appeared practicable parts had to be abandoned from unexpected expanses of water and quicksands that were come upon: ten days were lost in these endeavours, and Mr. Bond was well-nigh giving up the attempt as altogether impracticable, when, by taking advantage of the fall in the level of the water at spring-tide low water, and making a detour of 21 miles (so rounding the head of the creek), he had the satisfaction of reaching Kotri across the creek and opposite Lakhpat on the 27th March. But then, although the physical difficulties had been overcome, experience was altogether at fault in regard to the arrangements imperative for the continued supply of food, water, and carriage for the establishment, there being no villages whatever in the vicinity of the line between Kotri and Moghul Bhin, a portion of which forms part of the Rann. The detachment took three weeks to carry the line over these 45 miles to Moghul Bhin, where they were confronted by a new difficulty. From information received from the Executive Engineer, the periodical rise in the Indus was expected in a few days, which, if it occurred before the line of levels crossed the river, would have so flooded the country as to necessitate closing work for the season. Mr. Bond therefore lost no time in making a forced march to Sujáwal, leaving the section between Moghul Bhin and that place to be completed at convenience, where he embedded a permanent bench-mark; and, crossing the levels over the Indus at its narrowest part (then only about 300 yards across), he left another bench-mark at Tanka on the other side. Having thus placed the work beyond the risk of stoppage by floods in the river, the party retraced their steps to fill up the gap between Moghul Bhin and Sujáwal. Eventually, by the middle of May, the work was brought up to Tatta, and a week after, the programme for the season was completed by a connection being effected with the bench-mark at Chilia, which had been laid down 30 years ago, when the system of spirit levels was inaugurated at Kurrachee. It is interesting to note at this point that the comparison at this bench-mark showed a difference of only ⅞ths of a foot, the present value being higher than the former. As, however, the present line was carried over so many miles of difficult and unsteady ground, it was thought preferable to correct the values now obtained, so as to accord with those previously determined; the only correction to the latter being for the most recent determination of height of mean sea-level at Kurrachee. This line, which is 234 miles in length, with 43 miles of branch lines, was specially run with the object of furnishing values of height for several stations, of which the trigonometrical determinations needed correction before publication. To this end the levels were connected with 10 principal stations of the triangulation. Along the line, 22 bench-marks were embedded, and in addition the heights of 113 permanent points were determined: these will always be useful hereafter as points of reference. The results of this section will be published as pamphlet No. 5, Bombay Presidency.

The embedded bench-marks of both sections have, as usual, been handed over through the Civil authorities to the care of local native officials, who are held immediately responsible for their preservation.

A summary of the out-turn of the season's levelling is as below—

No. of miles of main-line levelled over	399 miles.
Do. branch-lines do.	63 „
No. of G. T. S. bench-marks embedded, including 4 for the special use of the Canal Department	37 „
No. of G. T. S. Stations connected	13 „
No. of additional bench-marks inscribed and whose heights were determined	296 „

On the completion of the season's work, the camp equipment and certain of the instruments were stored at Dhoráji (in Káthiáwár), for convenience in resuming work next season, a godown for the purpose having been courteously placed at our disposal by the Gondal Darbar. The thanks of the party are also due to the Cutch Darbar for the ready help, while working in that territory, invariably received from the *mamlatdar*, who was specially deputed to attend to the wants of the levelling detachment. The advice and assistance rendered by the Department of Public Works in Sind, and the collectors and minor revenue officials of Shahbandar and Jerruck, also call for acknowledgment in this report.

The programme for the coming year is to carry down a line of levels from Rajkot to Bhávnagar Tidal Station, and on to Shiyálbet (Port Albert Victor), where the tidal observatory will, it is hoped, be completed this winter. After accomplishing this, the detachment is to change ground, and beginning at Nándgaon (in the Nasik district) will

carry on a main line of levels along the railway line *viâ* Nagpore towards Bengal, so as to furnish a basis whereon to reduce hereafter and utilize the levels that have been executed by the Railway Department.

Extracts from a Report on the ISLAND OF MINICOY, *by* MR. G. BELCHAM, *Surveyor, 2nd grade.*

I arrived at Colombo on the 8th February 1890, and left in the S S. *Ceylon*, belonging to the Board of Trade, on the morning of the 13th for Minicoy, arriving there very early on the 15th. The vessel anchored near the small entrance to the lagoon, and at daylight we went over in a boat to the village of Minicoy, and landed right opposite the *Kacheri*,* which is a small *pucca* building with one room and a very spacious verandah, situated at the south end of the village and about a couple of chains from the bank.

One of the Amin's sons was on the beach with a small retinue to welcome us, and asked us to go to his father's house, as he had lately met with an accident and had sprained his ankle and could not leave his bed. So after we had taken some soundings in the lagoon opposite the Kacheri, we interviewed the Amin, who is a Mahomedan and is the headman of the village and invested with magisterial and revenue powers by the Collector of Calicut, under whose jurisdiction the island has been placed for some years back.

The Amin talks Hindustani, and I was thus able to tell him of my mission, and he seemed pleased at the thought of his little island being selected as the site of one of our observatories: he said he would be glad to give us every assistance in his power, but that he should be authorized first by the Collector of Calicut, as without his instructions he could do nothing. I gathered from the Amin's conversation that carpenters and labourers were plentiful, that they built their own boats, and consequently there would not be much trouble in setting up the observatory house on cocoanut piles at Minicoy.

* * * * "Captain Channer intended sailing the same evening; so, after taking a number of soundings opposite the Kacheri, where the depth of water was 9 feet at a distance of a chain from the shore, we made for the light-house, which is at the south end of the island.

* * * * The light-house staff at Minicoy at present consists of:—1 European, in charge; 1 Portuguese assistant light-keeper, and 4 menials (natives of Ceylon and Minicoy). The island is considered unhealthy by the light-house people, three of their number having died on the island within the last few years. The light-keeper and his assistant are relieved every three or four months; the Board of Trade have 5 light-houses under their control, and so the keepers are shifted about from one to the other. * * * * The menials employed at Minicoy light-house get R 20, and the assistant light-keeper (who is a man like the clerk at Cocanada, whom it is proposed to transfer to this observatory) R 60 a month with rice money. * * * * * The natives of the island are entirely dependent on Calicut for their supply of rice, *dál*, ghee, etc. There are four shops kept by some of the rich people, but at times their vessels are late in returning from Calicut, and at the time of our visit the Amin informed us that there was only ten days' supply of rice; it would be therefore necessary to make some arrangement for keeping our men supplied with rice and other necessaries. * * * The Minicoy merchants have about 10 big *dhonis* (small schooners) with which they trade with Calicut, Colombo, and even Calcutta; and the only time they are cut off from Calicut is between June and September. * * * *

Judging from the appearance of the islanders, the place seems to be healthy enough, for while passing through the village, I did not see a single man, woman, or child looking ill; they further seem to be in decent circumstances, from the fact of them all being well dressed. The people remind one of the Mahomedans on the west coast of India and are, if anything, better developed and more decently clad.

The Amin told me that fever and rheumatism are prevalent during the monsoons, and this is nothing surprising, as there is a very dense undergrowth of *keora* (*Pandanus odoratissimus*) and the common sea lily between the cocoanut trees, which grow in great profusion on the island.

The islanders keep fowls, but as a rule they keep them in reserve and only kill them when their supply of rice is running out. There are also a few goats and cattle, but these belong either to the Amin's family or to the merchants.

We saw plantain trees growing here and there, and the *pan* (betel leaf) is also cultivated to a small extent. The people are solely dependent on the produce of the cocoanut palms and on fishing for their livelihood.

The Amin told us that there are about 6,000 inhabitants, of which at least half are away as sailors in the P. and O. and British India boats.

I am indeed much indebted to Captain Channer for the great kindness and courtesy shown me by himself and his officers, and for the help he gave me in making an inspection of the lagoon with the view of selecting a site for the proposed tidal observatory.

Extracts from Notes by MR. J. BOND, *Surveyor, 4th grade, on the Levelling Operations executed by him in the* RANN OF CUTCH,—*Season 1889-90.*

On arriving at Lakhpat, on the boundary of the Rann, the local officials informed me that the tract was impassable for levelling operations, owing to the high winds then prevailing, the great spread of water, and numerous quicksands, also, because the owners of camels had all decamped with their animals, so that not one was to be found within a radius of 60 miles. I also found I should have to carry the levels for 75 miles, including branch lines, before I could come across drinking water after leaving Lakhpat. * * *

* While arrangements were being made to procure carriage and vessels for the conveyance of water in the Rann, I made several attempts under the most trying exposure and hardships to level across the Khori creek; but all proved futile, owing to the expanse and depth of water, and the numerous quicksands along the right side of the creek, which required the utmost care to avoid being swallowed up in. There was some grim amusement in witnessing the desperate energy with which one and all hurried over the more treacherous parts. Not being fully alive to the extreme danger I was incurring, I stood for a few moments in one position till a warning cry attracted my attention, and to my horror I found I was held fast, and with the greatest difficulty at last succeeded in extricating myself. The rectangular level was regained by the united efforts of the establishment, and immediately the sands swayed up and down like a huge monster in a rage at being deprived of its prey; and while the commotion lasted, a look of astonishment and alarm appeared on the countenances of all, as we awaited what catastrophe was to follow. To add to our discomfort, the boat with our supply of water grounded in the creek and had its bottom stoved in.

The experiences of these few days, and a knowledge of the extreme risks we should incur, should there be any failure in the transmission of water and supplies by the grounding of the boats and desertion of camel-drivers, placed me in a very critical position, and for some days I was undecided how to act. Eventually, I decided to make one more attempt, and, if it failed, to abandon the work as impracticable. On the 21th March I carried a forward section to Bhitara Bet, an island in the Rann, using pegs 7 or 8 feet long on which to rest the levelling staves; nearly the whole distance being under water and the ground

* This probably stands on the site of the house used by the late Captain J. P. Basevi, R. E., for his pendulum observations in 1865-70. There are some men on the island who remember his visit, but they were out, either fishing or away at Calicut.

very slippery, we were soon wringing wet and liberally besmeared with mud. The light equipment and supplies that were despatched on camels from Lakhpat in the morning shared the same fate and did not turn up till late in the evening; and then we heard that some of the camels had been left behind, having sunk up to the neck in the soft mud! For the best part of the following morning all hands were employed in digging out the camels before commencing work.

We reached Kotri, a rest-house and beacon for travellers, on the right bank of the Khori creek, on the 27th March, having levelled over a distance of 21 miles from Lakhpat. The work was laborious and fatiguing, and the agony of walking miles with lacerated feet over the beds of salt crystals is indescribable. Here we were able to get from the man in charge just sufficient water to quench our thirst, but all cooking had to be deferred till 8 P.M., when our water supply arrived.

On the 29th the working party marched out to Syad Ali, T. S., and carried a back section thence to Kotri; but finding that no water had arrived, we crossed the creek by boat and returned to the main camp at Lakhpat. * * * *

Being fully alive to the fatal effects that would ensue through the slightest mismanagement, the experiences of the past few days, coupled with the difficulty of having water regularly carried out to my camp, led me to abandon Lakhpat as a base. Having decided to run the risk of crossing the Rann in spite of all odds, every obstacle was simply an incentive to push ahead; and I now look back with pride on the achievement of the work, but no inducement would ever cause me to undertake the same again.

My remarks regarding the Rann refer only to that portion of it between Lakhpat in Cutch and Moghul Bhin in Sind, which the party actually traversed, where neither water nor food is procurable for man or beast, and where none of the vegetation and animals seen in the eastern parts are to be met with. Even mosquitoes, flies, and other insects which torment travellers unmercifully in Cutch, were not seen in the vast solitude of the apparently boundless salt-waste. Our solitariness was painfully oppressive, and only broken at midnight by the occasional passage of pilgrims on their way to the shrine at Narayan Sarovar (in Cutch), calling on their gods to pour down blessings upon the government; and on one occasion they held a special service near our camp in the dead of night (for no travellers ever attempt to cross the Rann by day), and prayed for the success of our enterprize, under the impression that we were pioneering for a line of railway!

While at Lakhpat, I was introduced to a native of Hyderabad (Sind), known as 'the doctor,' who combines the profession of *vakil* with that of a physician. He readily afforded me much useful information regarding the Rann, over which he had frequently travelled. He cautioned me against the danger of traversing it by day, stating that while one rarely escaped there were hundreds who died in the attempt: the traveller, he said, becomes giddy and stupefied, loses his way and moves about aimlessly in great fright, and soon dies of frenzy, coupled with exhaustion and thirst. * * * *

Lakhpat, which was formerly a large and important place, is now in ruins, and continues to be more and more deserted by its inhabitants, who now number only 600 souls. In anticipation of a railway passing through the place, building sites were rapidly disposed of during my stay. * * * *

The hot winds began on the 29th March, and they are fearful; the exposed skin is scorched, and books and papers curl up like burnt paper. * * * * At midnight of the 31st March the party started from Kotri to cross the Rann, and about 10 o'clock next morning reached Vehr. Here we were met by the *tappadar* (petty subdivisional officer) and a *taluk* peon, sent on by the *mukhtyarkar* (agent) of the Jati *taluka*. We also found two barrels of water sent on to us from Moghul Bhin, but what water! It was white, like dirty milk, of the consistency of treacle, and flavoured with turpentine and kerosine oil (the previous contents of the barrels); it was literally putrid! Besides these two barrels, we had three *pakhals* (large leather bags), which were all that we could obtain from the Cutch Darbar, and four metal pots for the Brahmins of the party; and this constituted our entire equipment for the storage and carriage of water. The *pakhals* had been preserved in castor oil! * * * * I had a filter with me, but it was perfectly useless, for the water put into it was too filthy and greasy to undergo filtration, and the filter soon became choked. I resisted as long as I possibly could, quenching my thirst with this nauseous mixture, but the burning pain in my stomach became overpowering. I have heard the expression 'burning thirst,' but never before did I realize what it meant. * * * * * * *

Between Syad Ali, T. S. and Ouni, T. S. the ground was strewn with the bleached bones of human beings, camels, cattle, and donkeys; those of the first can always be identified by the *badak* or earthen jar, the indispensable companion of all travellers in these parts, lying near, either broken or intact. This testifies to the terrible and inevitable fate of those unfortunates who lose their way in the Rann. It is strange that these were not seen anywhere else except in the vicinity of these two tower stations, apparently showing that lost travellers attracted by these conspicuous land-marks (about 25 feet high) attempt to make for them and die there.

Beacons, either huge fires or a lantern raised on a pole or attached to the instrument stand, were invariably shown at night to mark the direction of the camp to all stragglers too fatigued to reach it before nightfall. Owing to the overpowering heat, mirage, and the dazzling blinding glare from the ground encrusted with salt, which becomes intolerably painful, and causes a swimming sensation in the head, the party worked both in the mornings and evenings, and was not unfrequently benighted in the Rann. * * * * Not a blade of grass showed itself till we reached the vicinity of the Gadapwah. We were 20 days in the Rann, during which, I endured such mental anxiety and physical suffering that, when at last we reached a green spot at the end of the Rann, where our camp was pitched, a new earth, my delight was unbounded and my feelings so overpowering that I had to exercise great force of will to resist the inclination to roll with joy on the delightful green sward before the whole establishment, who would probably have thought me crazy. * * * * * * * * *

UPPER BURMA.

KYAUKSÈ DISTRICT.

Description of the country surveyed by MR. G. B. SCOTT, *Deputy Superintendent, in charge No. 3 Party, in the* KYAUKSÈ DISTRICT,—*Season 1889-90.*

The Kyauksè district of Upper Burma lies roughly between latitudes 21° 15′ and 21° 50′ and longitudes 96° and 96° 30′. Its total area is about 1,050 square miles, of which, however, about 350 square miles is a wild and almost uninhabited part of the Shan hills, known as Ye Yaman, which has lately for administrative purposes been incorporated in the district. The remainder is generally a level tract interspersed with low hills, or groups of hills, rising from 600 to 1,600 feet in elevation. It is separated on the north from the Mandalay district by the Myitnge river, which, after a long and tortuous course among

the mountains, here enters the plains, and taking a westerly course, falls into the Irrawaddy about 20 miles lower down. On the east lie Ye Yaman and the Shan states of Baw and Minetzauk. On the south it is divided from the Meiktila district by the Pekwe groups of hills, an off-shoot from the Shan hills. On the west the boundary follows the Samon river for 12 miles northward from the point where it enters the district, then it takes a semi-circular sweep westwards with a radius of 8 miles, and returns to the Samon at a point 12 miles lower down; thence it follows that river 9 miles to its junction with the Panlaung, which river then forms the boundary for 10 miles to its junction with the Myitnge near Ava.

Rivers.—The Myitnge river which winds along the northern boundary, with many twists and turns, is most picturesque. It is from 250 to 350 yards across, and at all times contains, within high firm banks, a large volume of beautifully clear water, shaded on both sides by numerous mango groves, among which are numerous villages, with here and there well-built masonry pagodas and teakwood *sayats*. The water seldom, if ever, rises above the banks, and as its level is lower than that of the country on either side, it is not utilised for irrigation. Dug-outs are kept at every village along its course, and large rafts of timber and bamboos are brought down it from the hills. It is navigable by small steamers for some distance beyond Ye Yaman.

The Samon and Panlaung rivers enter the district at the south-western and south-eastern angles respectively; the former with many twists and turns takes a northerly, the Panlaung, equally tortuous, a north-westerly course till they meet, and then flow onwards to the Irrawaddy. The Zawgyi enters the district from the Shan hills, about 16 miles north of the Panlaung and winds, first eastward, then northward, till it, too, enters the Myitnge. The Samon, except during heavy rain, contains very little water, but the Panlaung and Zawgyi rivers, draining large areas in the hills, bring down volumes of water sufficient at all times of the year to irrigate fully 500 square miles of country.

Canals.—From these rivers numerous canals are conducted on every side. These canals are the most remarkable feature of the district and the chief source of its wealth. They are said to have been first excavated in the year 427, Burman era, A.D. 1065, or the year before the Norman conquest of England, by King Nawyate, whose capital, Myinzoung, lies about 6 miles east of Kyauksè, where the remains of the fort and numerous pagodas crumbled or crumbling into ruins may yet be seen. For this system of irrigation the country is specially adapted, there being only a fall from about 300 feet above sea-level at Ingon where the Panlaung enters the plains, to 200 feet, where it falls into the Myitnge, the fall having a general tendency from south-east to north-west along the course of that river. The principal canals are, from the Panlaung, the Ngalinzin, which, turned off by a dam near the hills at Ingon, flows northward along the base of the Shan hills and waters the bulk of the Sawhla township, as the south-eastern section of the country is called; the Natlwe, which flows westward, watering the country between the Panlaung and the Pekwe hills; the Paungbya and Thongyi, continuing the work of the first canal and carrying on the irrigation across the railway lines to the Panlaung; and the Kyinye or Samon, irrigating the tract between the Panlaung and Samon rivers. From the Zawgyi are the following canals: the Nevadel, running south-westward, which aids the waters of the Panlaung; the Ngapyoung and Thingdwe irrigate the low plain south-east of Kyauksè and the latter, continuing its course, cuts through the eastern end of the Kyauksè hills, waters the country to the north-east of Kyauksè and empties what is left into the large Thingdoungeng marsh near Belin railway station; the Zeedaw, starting near Kyauksè, which waters the country east of the railway line, and continuing northwards, empties into the Mihlanhan, a marsh or lake, 3 square miles in area, where it is dammed, and utilised as required for irrigating a large tract between the hills and the Zawgyi.

Starting from Kyauksè itself, and draining off the last of the water from the Zawgyi, is the Paleik canal, which now virtually becomes the river, and was, till the advent of the railway, the only line of communication with Ava and Mandalay. From this point, the Zawgyi is a dry creek covered in with thorny bushes and reeds, though it has been calculated that over 12,000 cubic feet of water per second are discharged over the Kyauksè dam. From the Paleik is drawn off the Myongzon and other lesser canals, which, with the Paleik, irrigate the whole country between the Zawgyi, Panlaung, and Myitnge rivers. The dams, or *ses*, at the various canal mouths are roughly made of double rows of stakes, filled in with large rough stones. These were kept in order by parties of villagers, but are now under the superintendence of the Public Works Department, with the following establishment, besides the Executive Engineer—1 Assistant Engineer, 1 Irrigation Myoke, 10 Ségyis, 11 Segoungs, and 220 Sebinthas.

Innumerable lesser canals and irrigation channels are conducted from the large river, and intersect fully two-thirds of the district in all directions, making communication, even on foot, across the district very difficult. Over the Zawgyi at Kyauksè, over the Panlaung at Dayegaon, and in some other places, large teak bridges were built before the British annexation, but all other bridges are as a rule mere creaky planks, barely fitted for foot-passengers, and out of repair. If the bulk of these were improved, travelling would be greatly simplified; as it is, the traveller must be prepared to wade, at intervals, knee or waist-deep, whether his way lies across fields, along village foot-paths, or even along what, in other districts, would be called district roads. The banks of the streams and canals are usually covered with thorny bushes and creepers, which do not tend to improve matters for the traveller.

Rice lands.—These irrigated rice lands extend longitudinally across the district from south-east to north-west, and cover, at present, an area of 200 to 250 square miles, which, however, could be largely extended. Here, at any time during the year the various operations of ploughing, sowing, and reaping may be seen in progress simultaneously in contiguous fields, each tenant letting the water on and off his own fields without reference to the season of the year. The ploughing of these fields is most laborious. The buffaloes and cattle are strong and well cared for, and need to be, for they must strain every nerve to drag the plough through masses of clay in which men and cattle stand knee-deep. The result is that they circle round and round and seldom succeed in reaching the edges of the fields: these in many parts are in consequence circular, and between each the *mendhs* or *kasins* are broad and high and covered with fine grass for the cattle.

Other lands.—The country to the east of these lands up to the Shan hills is slightly more elevated, and is covered with bamboo or scrub jungle. Even here, however, at intervals are villages surrounded by large areas of unirrigated lands, on which are raised great quantities of tomatoes, chillies, *sesamum* (*til*), Indian corn, and other dry crops. To the west of the Samon the country is all unirrigated, the crops depending on rainfall; and the villages are few and small, obtaining their water-supply from tanks and wells. The supply however is not very abundant owing to the scanty rainfall, which last year was only 21 inches, and of which 15 inches fell between May and September. This year scarcely 6 inches fell between the middle of April and the end of August; the total rainfall to date this year has been only 10 inches. The hottest time of the year was in March and April, when the thermometer rose to 110°; the maximum in July was about 92°, and in December 82°: the averages at the three seasons were 83°, 80° and 70°, respectively. In parts, a small quantity of wheat is raised on the uplands: there is nothing to prevent wheat becoming hereafter much more largely grown.

Groves.—Along the Panlaung river and the larger canals are extensive groves of toddy palms (from which large quantities of sugar are extracted), betel-nut palms, *pan* gardens, and plantain plantations. These last now cover thousands of acres, and they are rapidly extending, the fruit finding a ready market in Mandalay, as well as in Kyauksè.

Villages.—The villages, generally buried among trees, are mere collections of thatched huts, with slightly-raised floors; but in or near most of them are neatly constructed teak-wood *Phoongyi kyoungs* (monks' schools), and *zayats* (rest-houses) and masonry pagodas. The *zayats* usually afford ample shelter for small parties, and were of great use to our men.

Fairs.—Fairs and markets, either daily or weekly, are held at various centres all over the country, where, in addition to rice, fruit, vegetable, and leaves of various kinds, may be seen large quantities of the bright-coloured *patsos* and scarves from Manchester, which are fast superseding the stronger but more expensive local article.

Towns.—Kyauksè, which boasts a municipality, is the central town of the district, but Paleik on the Myitnge is much larger. The population of Kyauksè is said to be about 6,000. Other fair-sized places are Myittha, Kumè, and Dayegaon, etc.

Marshes.—There are several large marshes in the district, formed where the canals empty their surplus waters; the principal ones are the Thingdoungeng near Belin; the Minhla kan near the hills on the north-eastern border, and the Paleik and Singaing. These could, I believe, be all easily drained, and thereby several square miles added to the cultivated area and the localities made more healthy.

Hills.—The Shan hills, fringing the eastern limits of the district, are rugged masses, rising in places to 3,000 feet. The "Crag" or Taung Magye, 2,600 feet in elevation, which overhangs the Myitnge, looks very imposing, especially as seen from Mandalay. The ascent is sheer from base to top, the height of the river here being only about 350 feet above sea-level. Other isolated hills and groups, forming a total area of 60 square miles, lie interspersed within the level tract. These, as well as the skirts of the Shan hills, are almost bare of soil, and are waterless and rocky: coarse grass and scrubs grow over them, but they are unfitted for cultivation. Several have vast chasms on their summits, of which some formed excellent hiding-places for dacoits. There is a singular exception in the low hill or spur lying near the base of the Shan hills, where the Panlaung debouches into the plain, thus commanding the road through the Nateik pass into the Shan country. The top of this hill is flat, and across it is carried a stream of water brought across the *col* from the higher hills, which is used to irrigate the plateau on which lies the present village of Kinlat. The old fortifications and hills are known as *Belu Myo*, or "city of demons," but who first built the walls is unknown; they are now partially retained by lines of telegraph wire.

People.—Except in the sub-divisional towns, the people are almost pure Burmans, with here and there a Shan or Dhanu (half Shan, half Burman) village. To judge from their every-day appearance, they are neither so wealthy, comfortable, or happy as their brethren in Lower Burma. Yet on festival days they, too, can assume the brightest of holiday-clothes and faces. They seem very peaceable, and loud domestic quarrels, so common in Indian villages, are seldom heard. The children seem stout, jolly and healthy, hopscotch and kite-flying being very common amusements, varied by dancing, in imitation of their elders. Gambling on a small scale at "odd or even" is common, and occasionally a big stroke is made. Toddy is extracted from the palm; rice-beer is manufactured for local use, but there is little intoxication. The Chinese retail-liquor merchants in Kyauksè and other places, are forbidden to sell foreign spirits to Burmans, and this order is rigidly enforced. Pilgrimages to Kyauksè pagoda and other holy places, entail a good deal of climbing and much laughing and joking. The produce of the rice-fields and groves finds a ready market

at the railway stations or in Mandalay, and good prices are obtained. The cattle are very fine and well kept, and need all their strength for the hard work of ploughing, at intervals throughout the year, in fields heavy with mud, in consequence of which large numbers of the rice-fields are circular in shape, the corners not being squared off and having *kazins* between them, varying from 20 links to a chain in breadth, and often 2 to 3 feet above the fields in height.

Statistics.—The total cultivated area is about 300 square miles, of which fully two-thirds are irrigated rice lands, producing two, and even three, crops a year. There are also 200 square miles of fallow, and 10 of groves and gardens.

Population.—The total population last year, according to the administration report, was 81,700, giving an average of 77·81 per square mile over the whole district. But, really, the total number of houses in Ye Yaman is only 200: The population cannot, therefore, be much over 1,000 in the 500 square miles of those hills. This leaves 80,000 for the remaining 600 square miles, which gives an average of 133 per square mile in Kyaukse proper, which is nearer the mark.

Shan trade.—From the Shan hills to the east large droves of bullocks bring down dried leaves for cigars, catechu and other forest produce, returning with cloth, etc. They enter Kyaukse from Yatzauk and other states in that neighbourhood by the Nateik pass to Ingon and on to Myittha railway station, whence they go by train to Kyaukse and Mandalay. Others, but not in such large numbers, come down *viâ* Myogyi in the Zawgyi valley. The Kyaukse municipality are endeavouring to secure funds to provide ample accommodation for these useful traders in that town. The Nateik pass could be much improved with advantage; beyond that the route through the Shan hills is fairly easy, over undulating slopes from 3,000 to 4,000 feet above sea-level. The valley of the Zawgyi, which ascends by a very gentle gradient to its source, should present no engineering obstacles to the construction of a railway, except perhaps between some cliffs about 50 miles above Myogyi, which, however, in all probability would not be found insurmountable. The valley is at present almost uninhabited beyond Myogyi, and winds between hills covered with forest. The water for many miles is waist-deep, except at certain points, where in dry weather, rocks show near the surface and render it at present unfitted for boats. Rafts come down at all seasons lightly laden, but at such places have to be unloaded and often broken up.

Ye Yaman.

Ye Yaman lies between latitude 21° 30′ and 21° 40′ and longitude 96° 15′ and 96° 45′ and is a township of the Kyaukse district covering an area of about 350 square miles of hills. It is bounded on the north by the Myitnge river; on the south by a range of hills which, rising abruptly from the plains in a craggy hill 2,000 feet above sea-level, above the village of Kale (near which the Zawgyi river passes the last hills along its course and enters the plains on both sides), runs for nearly 30 miles almost due eastward at an average distance of about 10 miles from the Myitnge, then turns northward, opposite a corresponding bend of that river, and at length falls into the river itself about 15 miles from the bend. On the west lie the plains of Kyaukse and to the east the Shan state of Yatzauk. The southern range which, from its most prominent peak, might be called the *Walu* range, divides Ye Yaman from the Shan state of Myogyi or Baw, and the Myitnge on the north divides it from the Mandalay district.

The highest peaks of the range, *viz.* Walu, Hnimban, Taunggyi, and Zeitkhè, rise to 4,500 and 5,000 feet, and from them are thrown a series of spurs with intervening watercourses, generally dry, northward to the river, which is here about 400 feet above sea-level. The few villages which lie on the Myitnge, or on these streams, consist of small clusters of bamboo huts, the inhabitants of which are very poor; they cultivate only a few acres of tomatoes, chillies, Indian corn and other dry crops, and obtain a living by selling bamboos and bark of trees for rope-making, *kath* or *sagyi* (catechu), and a resin called *indo*, used for making baskets waterproof. On the higher hills are a few pine trees (*longifolia*), stunted oaks and acacias. The lower slopes are covered with small-sized *sal* trees and the dry valleys with bamboos of various kinds, some of which are very fine.

Most of the villages, or rather hamlets, lie along the course of the Myitnge, and consist of small clusters of bamboo huts. Going up-stream after passing the "Crag," above what is known as "Gastrell's Camp," from the first officer in charge of the post stationed there to guard against dacoits, they are as follows:—

Hanetgyiteik, about 4 miles east of the "Crag," once consisted of a few huts, but is now deserted. Four miles further up is Thayetpin, a deserted hamlet, once consisting of about 15 huts. Yè is about 3½ miles further up-stream, and consists of some 35 huts and a *pongyi kyaung*. Here are a few acres of tobacco, tomatoes, etc., but no rice. Rice for consumption is purchased at villages down the river or taken in exchange for bamboos and brought up the river in dug-outs or in carts by a track along the river bank. Opposite Yè, on the Mandalay side of the river, is the hamlet of Gwebin, now almost deserted. Three miles farther up-stream is Kyaung, consisting of a *zayat* and about 8 huts, with some five acres of cultivation; another mile up-stream is Yaman, 20 huts and a few patches of cultivation. Another 1½ miles up-stream is Selin, with 10 huts but no cultivation. Two miles farther is Yegyan, a deserted site. This is the last hamlet of Ye Yaman along the Myitnge. Near it a large but dry watercourse falls into the Myitnge. Some 2 miles from the river are a few huts known as Ywama. Near the source of the stream on a small

plateau is Zeitkhye or Malaka, 15 huts, occupied by Dhanus (half Shans), who carry on *joom* cultivation on hill slopes, over a few acres. Ungyo is said to be a village of 40 huts, on the crest of the range 8 miles beyond Zeitkhye, occupied by Shans and Dhanus, who cultivate about 100 acres of maize, *til*, and other dry crops. This village is said to be on the watershed, the hills beyond falling south-eastward to Thondaung in the valley of the Zawgyi river, in the Yatzauk state.

There are a few other hamlets:—One known as Pyettaw, is now deserted, but was once a safe resort for dacoits; it lies on a bamboo-covered plateau about 4 miles south of Thayetpin, and is the resort of herds of wild elephants. The hamlets of Kyaungzaung, 35 huts, Yethazauk, 20 huts, and Tonghla or Ywathit, 10 huts, lie on the Chaola watercourse, which falls westward from the Walu peak, into the plains near the village of Pyaukseitpyin. There are small supplies of water near each hamlet, and a fine spring near Yethazauk and another within half-a-mile of the crest of the Walu peak. The Kyaungzaung supply is a small well, dug in the bed of the stream, about 3 feet deep, while Ywathit is supplied by a fine stream of water, which runs here above the surface for 100 yards or so, and then sinks into the sand and is lost. The people of Pyaukseitpyin have to come here for water during the greater part of the year. The only tax paid by the peasantry in Ye Yaman is a house-tax of ₹10 per house per annum, and the total realized is ₹2,000 a year. Most of the country must always remain unculturable, but irrigation should allow of a fair slice of highly-cultivated land being formed along the banks of the Myitnge.

Bhamo District and Momeit State.

Extract from the Narrative Report of Major J. R. Hobday, S.C., *in charge No. 21 Party—Season 1889-90.*

On the 15th December 1889 I started with an expedition organized to punish the Kachins, inhabiting the hills about 50 miles due south of Bhamo, and to capture or kill one Kanhlaing, the ex-Sawbwa of Mohlaing (Möngleng), whom these Kachins had been harbouring for some time past. In three marches along a flat *terai* country we reached Sikaw; and another march brought us to the foot of the hills. Learning that the direct approaches to our objective were strongly stockaded, it was determined to advance by a circuitous route known as the Lwèlet or Lwoilet road, which led through friendly Kachin villages to within a march of Lwèsaing, or Lwoiseng, the first of the enemy's villages.

Lwèsaing was captured on 24th December, after some resistance, and burnt. The following day more stockades were attacked, and Tonhon, another large village, was occupied. A detachment had been sent down the hill to secure the ferries across the Shweli river, but failed to cut off Kanhlaing, who evaded our vigilance, and got safely across during the night, on rafts, between two of the points on the river, held by us. We remained at Tonhon till 3rd January to obtain the submission of, and extract fines from, the neighbouring villages subject to the Lwèsaing-Tonhon Kachins.

Our next mission was to march across a difficult and mountainous country towards Manton, in the heart of the Momeit state, in search of Saw-Yanaing, one of the Chaungwa princes, who had been a fugitive in the Shan states for some years past. At the same time another column advanced on Manton from Twin-ngè on the Irrawaddy *viâ* Momeit. From Tonhon we descended to the valley of the Shweli to a point known as the Namtwè ferry, but we found no boats, so had to set to work, and construct bamboo rafts for the passage of the troops. This operation took us the greater portion of two and a-half days, the Shweli being about 100 to 150 yards broad, and the current swift; the river running in a succession of rapids, with only a pool here and there. From Namtwè we successively marched to Ngwansai, Möngkak, Lwoikang, Nampao-chaung, Koukkyaing and Wamang, through a difficult and mountainous country.

The hills at Tonhon attain an altitude of from 3,000 to 4,000 feet. The country was sparsely inhabited by Kachins and Palaungs, who had been carrying on a warlike strife for supremacy for many years past. However, we met with no opposition till we reached Wamang, which was captured on 10th January, and Manton on the following day, and so well had the advance of the two columns been timed that they met simultaneously at Manton with no small danger of exchanging shots at each other during the attack. Saw-Yanaing of course had made himself scarce at our approach.

I remained at Manton till 21st January; during this time we had some sharp skirmishes with the enemy whilst attacking surrounding villages with the worst of the butcher's bill, as generally happens in this class of warfare. On 16th January Lieutenant Daly met us from Möngtat, thus enabling me to examine Faida Ali's surveys. At length hostilities ceased, and the enemy began to show signs of submission; moreover, the Tonhon column was ordered to hold fast at Manton for an indefinite period; so I left it on 21st January, and joined the Momeit column, which then advanced to Manpun (Binbon), in two marches, across some more stiff hills.

Here we remained about a week, when hearing that our old friend Kanhlaing was again hovering about in Mohlaing, we started off in pursuit *viâ* Paw-an, Yabon, Pangkouk, Lwoichi, Wegyi (Molo) and then across the Shweli to Lwèwein, but, of course, he

had moved on before we arrived. We remained at Lwèwein, a Kachin village situated on the top of a range of, hills running parallel to, and west of, the Shweli river, till 6th February, reconnoitring in various directions. We then heard that Kanhlaing was in the Nampaw valley; so moved on to Kyungyaung in the plains.

Here again, failing to catch Kanhlaing, we made prisoners of about a dozen headmen of villages, including his brother-in-law, who had been helping him in funds, &c. With a small party these prisoners were started off towards Bhamo; but, just as we were entering the village of Sipein, the first march from Kyungyaung, the brother-in-law in a plucky way broke loose from the Gurkha escort and effected his escape in the jungle. Back we returned to Kyungyaung, and it was decided to hand over the prisoners to the Sawbwa of Momeit. When it became evident that active operations had ceased, and as I had completed most of the topography that was possible, I took the opportunity of going with these prisoners under an escort of a native officer, and 20 Madras sepoys. I left the column on 12th February, and returned by an entirely new route *viâ* Wegyi (Molo), Nayok, and Paungadaw to Momeit, where I arrived on 15th February. I halted there a day, and proceeded to Mogok (Ruby Mines), by what is known as the Kyauktada road, halting at Konwat *en route*. From Mogok I followed the new cart road to Thabeitkyin on the Irrawaddy, and finally arrived at Mandalay on the 25th February, just in time to supply my other survey parties with funds, of which they were now in need.

ANGLO-SIAMESE BOUNDARY COMMISSION.

Report on the Survey Operations with the ANGLO-SIAMESE BOUNDARY COMMISSION, *by* CAPTAIN H. M. JACKSON, R.E.,—*Season 1889-90.*

The survey detachment started from Rangoon with the rest of the Commission on the 18th of November 1889 and arrived at Fort Stedman in the Shan States on the 1st of December. From this place, after a long wait for orders, Mr. Ogle was detached to proceed *viâ* Monè and Maing Pan to survey the eastern frontier watershed of the "Five states." For this he was equipped quite independently, and it was arranged conditionally that he should work southwards to meet the rest of the Commission, who were to work from about the southern part of the frontier northwards. I sent with Mr. Ogle two sub-surveyors, Shadi Lall and Abdul Rahim. His orders were to check the triangulation at Monè and carry it on through Maing Pan across the Salween, and then work southwards triangulating, surveying the frontier watershed in question, and getting in as much of the country as possible *en route*. These instructions he carried out most successfully.

The main body of the Commission left Fort Stedman on the 16th December, and marched south through Karenni *viâ* Sawlôn to Yuathit. On the way, by starting two days ahead, I considerably improved the triangulation. From our camp at 'Ta-Sanglè on the Salween about 4 miles east of Yuathit, three parties were detailed by the Commissioner to strike different points on the frontier watershed. Mahmud Hosein was sent with the southern one under Mr. Ney Elias (in charge of the mission); Mr. Doran with the middle one, up the Mè-Pai with Mr. Archer (British Consul at Zimmè), and I accompanied Mr. Scott (Superintendent, Shan States) with the northern. The southern and middle detachments were hurried in their movements by political considerations, but obtained the necessary points, though without mutually connecting or getting in much country. My party began by marching five days up the left bank of the Salween, which in these parts lies about 3,000 feet below the tops of the main spurs running down to it, so that surveying any of the surrounding country was a matter of some difficulty. After the fifth day's march, however, we struck eastwards up the valley of the Me 'Sati and reached the frontier ridge, where a short halt enabled me to get in a good deal of useful geography, just reaching Mr. Doran's work, and to connect the triangulation, which was hence carried on to meet Mr. Ogle's in Möng Ta. From the frontier we returned by a slightly different track to the Salween at 'Ta Tawmaw, and recrossing at this ferry, found the rest of the Commission camped near Sadaw, the other survey detachments having reached this place with it by the right bank of the river. From Sadaw the party was again split up in order to reach a point from which we could strike into the state of Möng Maü by rounding the high ridge of the Loi Lan. This time I took Mahmud Hosein with me, to carry on the traversing of the river, which I had found difficult to combine with climbing up and down 3,000 or 4,000 feet every day in order to see round: Mr. Doran went with the main body. We scrambled along the right bank of the Salween, carrying most of the baggage, &c., in the boats, as the road was almost impassable for even "Panthay" mules with any loads up, until we reached the mouth of the Tein river. There we crossed and, after two marches on the left bank, came up with the rest of the party on the stream of the Long Wai, they having come round by Kadugyi and the ferry of Ongmai. From this we all went together to Möng Maü, where a few days' halt enabled a little work to be got in and the survey party to get a start ahead and to scatter a little, so as to map more country. The haze was now rapidiy stealing up, but fortune favoured me so far as to allow me, from two high points over the MèSakun valley, to connect with two points of Mr. Ogle's triangulation. On reaching the main road again, I found myself left two days behind and ordered to follow up quickly. On picking up Mr. Doran and the sub-surveyor, I took the former on with me and left the latter behind to get in an important doubtful part of the watershed between Möng Maü and Mè Sakun, and to map the remaining detail of the valley. Arrived on the ridge between the Mè Sakun and Mè Ta, I completed the connection of our triangulation on

almost the last day it would have been possible to do so, as the haze was now well set. Two marches more brought me up with the Commission, which I found had been kept waiting a day on my account. Mr. Ogle was with them, so the bulk of our work was practically done. The Commissioner had here arranged to send Mahmud Hosein back to the southern part of Trans-Salween Karenni, which had been hurriedly visited at the beginning of the work. His orders were to complete the mapping of this country, more particularly as regards the frontier of course, and then, working south down to Chauknyet, to reach Moulmein *viâ* Hpapôn by the usual trade route. It was also arranged to send Messrs. Ogle and Doran back to Monè by a different route, as there was nothing else for them to do with the Commission. We, therefore, all three stayed at Möng Ta, working at computations and traces until Mahmud Hosein arrived, the rest of the Commission going on northwards.

From our camp on the Long Wai abovementioned Mr. Scott, and Captain Pink (Intelligence officer) had left us on a mission to the distant state of Kyaington (or Kengtong). They went back to Monè, where they re-equipped and then proceeded by the 'Ta Kaw (ferry) and the northern road, returning by the southern one through Möng Sat and Möng Po and recrossing the Salween at the 'Ta Pyen. Thanks to Captain Pink and his two military surveyors, these two routes were very completely mapped as far as was possible at their rapid rate of travelling, and the loop thus obtained fitted in very well with the survey work at either end and with Garnier's map latitude of Kyaington. I had provided the mission with a pocket sextant in the hopes that a latitude might be observed; but circumstances prevented this.

Having despatched Mahmud Hosein on his southern work, which he carried out successfully, and Messrs. Ogle and Doran with sub-surveyor Shadi Lall to Monè by the Paleng ferry and Maing Pan, I proceeded with sub-surveyor Abdul Rahim to follow the Commission, which we caught up at Möng Hang. Thence we all went on together to Möng Tön, the northernmost part of Mr. Ogle's work. From this place I struck eastwards across the frontier ridge to Möng Sat, to ascertain whether this state lay entirely in the valley of the Mè Khok. Having stayed one day at Möng Sat so as to get in something of the geography of the place, I returned to Möng Tön, and thence followed by as long marches as possible to Monè, where I arrived on the 30th of March, and found the Commission waiting for me.

I may mention here that we had met both the officers of the Siamese Government Survey,—Mr. McCarthy near Möng-Maü and Mr. Collins near Möng-Tön; but I regret to say no co-operation was possible on account of the relations of the two Governments in the matter of the Commission. I was able to give both officers, however, some roughly worked out data of our points, which may possibly form a basis for future geographical combinations. The system employed in the Siamese Survey is apparently purely geographical; *i.e.* the work is carried on by star and sun observations for latitude, by chronometers for longitude and by compass traverses for distances and detail. The position of Chiengmai (Zimmè) has been fixed by the stars and by telegraph with Bangkôk. But the triangulation in Siam has not been extended beyond the capital where it was taken in 1878-80 by Captain J. Hill, R.E., in connection with the principal triangulation on the Burma coast.

Our special work was now over; but I knew that without improving the triangulation between Monè and the Tabet valley, there would be a considerable chance of the whole of that work remaining *pro tem.*, more or less in the air. I therefore urged that I should be allowed to remain at Monè with Mr. Ogle until the rain had cleared the atmosphere a little, and then work the triangulation back in a thorough manner on to a secure basis The Commissioner agreeing to this, we were left, and with us Abdul Rahim, that we might get some detail filled in *en route*. Mr. Doran and Shadi Lall went back with the Commission. During our wait at Monè, the time was most usefully occupied in computing the triangulation as far as possible, while Abdul Rahim filled in some new country to the north. At last, on the 6th of April, the rain began and having our transport in readiness, we were at once on the move again; working round north to Panglong and then south through Maingseik and so westwards across the Tabet valley by Banyin, we effected our purpose in about three weeks, arriving at Fort Stedman on the 30th of April. Here we were delayed some days for transport; but eventually got away on the 5th of May and reached the railway by the new cart road on the 12th. I found orders awaiting me to proceed to Myingyan and take over charge of No 11 Party, and also received news of Mahmud Hosein's safe arrival at Moulmein. Mr. Ogle returned to Rangoon.

Description of country mapped.—The Trans-Salween Shan States and Trans-Salween Karenni are bounded on the east (roughly speaking) geographically and ethnologically, by the first north and south water-parting to the east of the river. From this ridge, which varies in height from 3,000 to over 7,000 feet, several considerable streams run down into the big river, affording fairly fertile valleys, in which the emigrant Shans and Karens have settled at various times, though, nowhere, except perhaps in Méhongson, have circumstances allowed of these people attaining to much prosperity. Hence, the country is still mostly covered with jungle, and the export of teak logs by floating into and down the Salween forms the chief support of the country. A great deal of the best teak has indeed been already cut; and it is only up the more out-of-the-way valleys or hillsides that one sees big trees. At a height of about 3,000 feet and over, there is a good deal of pine, apparently the same as in the western states. The cultivation, such as it is, is entirely rice, with a little sugar and tobacco, nearly all for home consumption. The Salween, which is navigable with no great difficulty for dug-outs throughout these parts, is, of course, the great

highway of the country; but it is by no means over-burdened by the traffic, owing to the difficulties of the river lower down, and the limited demands of the countries on its banks. The other roads of the country are extremely primitive; no baggage animals except the basket-carrying bullocks of the Shans, or the pack mules of the Panthays, could use them. However, there is little need for good roads, as there is practically no traffic through the country, the Karen settlers being content with the products of their fields, and the Shans being in a continual state of "under which king, Bezonian?", a condition not conducive to the encouragement of trade. A certain amount of betel, though, passes westwards, and of salt and tobacco eastwards, through Möng Maü principally. Of the two more prosperous states, the relations of Mèhongson are mostly with Siam and of Möng Sat with Kyaington. The Shan spoken in all the Trans-Salween States tends towards that of Siam. In fact, there has, no doubt, been a long period of slight and varying pressure from east and from west into these states, sometimes western Shan and Karen preponderating, sometimes Siamese Shan. Hence, a gradual admixture of habits, language, claims and relations, which renders division on considerations of race a matter of considerable difficulty. Under a more assured and stable rule these states are undoubtedly capable of development; but a good deal of clearing is required to begin with, for which many more hands than the country now holds are necessary. Not much was seen of the wild animals of these parts; but tracks of bison or wild cattle were frequent, and the eastern variety of the wild dog (*Cuon rutilans*) was seen. Some pheasants shot were found to be identical with specimens obtained in the Chin hills, *viz. Phasanus humei*. The cock of this species is an extremely handsome bird.

As regards climate in the valley of the Salween itself, it is hot even in December and January during the day, the temperature falling very rapidly after sunset owing to the broad stretches of sand frequent along the banks. In Möng-Maü, at nearly 2,000 feet above sea level, it is pleasant enough. The other more northern states all lie too low for a temperate climate.

The following are a few maxima and minima observations of temperature taken at odd times:—

		Max.	Min.
In the Salween Valley, height about 600 feet, in	January	90	58
„ Möng Maü „ 3,000 „	February	83	47
„ Mè Sakun „ 2,400 „	„	80	55
„ Möng-Ta, Chut, Hang and Tön, height about 1,400 to 1,700 feet in February and March		93	53.

These, being means of but very few readings, are of course, of no use as statistics, and can only give a very rough idea of the temperature of these countries.

CHIN-LUSHAI EXPEDITION.

LUSHAI HILLS.

Report on the Survey Operations with the CHITTAGONG COLUMN, CHIN-LUSHAI EXPEDITIONARY FORCE, *by* LIEUTENANT W. J. BYTHELL, R.E.,—*Season 1889-90.*

The party embarked at Calcutta on board the I. M. S. "*Dalhousie*" on the 20th November 1889 and arrived off Chittagong on the evening of the 22nd, disembarking next day at noon. At Chittagong I received verbal orders from Brigadier-General Tregear to proceed to the front at once, as far as Lungleh.

Accordingly the party left Chittagong on the morning of the 24th, being towed up the river in flats, by a small steamer, and in company with 400 men of the 2-2nd Gurkhas under Major Begbie. At Rangamati we changed into small 'dug-outs,' which took us as far as Peshki-Serra, where the instruments, &c., were taken by bullock carts, round the rapids to Burkhul. Here we embarked again in 'dug-outs,' and arrived at Demagiri on the morning of the 29th November. We were detained here, owing to the commissariat not being able to issue rations to the party, until the morning of the 4th December, when we left Demagiri for Lungleh. I had intended to proceed from Demagiri to Sirtay and Uiphum to clear a station on each, but I found there would scarcely be time for this, so abandoned the idea.

At Demagiri Mr. Stotesbury made a plane-table sketch of the station and river on the scale of 12 inches to the mile.

Early on the morning of the 4th, I took over from Captain Montagu 40 Punjabi coolies from his gang. I may mention here that these are about the very worst class of coolies that we could have had for our work. To begin with, they are all tall men and only carry loads (not 40lb.) on their heads, and they seem to be able to carry them in no other way. The consequence is that when going along a half-cleared Kuki path the loads catch in every overhanging branch, bamboo, or stalk of grass, and their rate of progress is painfully slow. They are weakly men, constantly getting sick, insubordinate, and altogether gave far more trouble than they were worth. It was only when marching down country, on our return from Lungleh to Demagiri, that they seemed to wake up at all, doubtless, due to the fact that their noses were pointed towards home. I would suggest that in further work in such country none but Khasia coolies be employed: they are slightly more expensive, but they carry double the load and can keep up better and go faster than the Punjabi. They are also very useful in jungle-clearing work, for which the Punjabi

coolie is practically useless, and by carrying their loads on the back by a broad band over the head, they can go through any half-cleared path.

In addition to our 40 coolies, who were to remain with us permanently, we were supplied with 12 mules and extra coolies by the commissariat, to carry rations, &c., as far as Lungleh.

After rather slow marching (on account of the mules) we reached Lungleh on the morning of the 9th December, where I found Major Leach, Captain Mullaly, and Lieutenant Kingscote, R.E., who were just starting the clearing towards Teriat for the 'Haka road.'

On the 10th we all went up to Saipuya's old village site, on a hill top some mile-and-a-half north-east of Lungleh stockade. It was greatly overgrown with grass, but we found the tree observed-to by the late Lieutenant Pollen during the previous expedition, and after a good deal of searching, a portion of the stone marking his station, with the circle and dot still on it, but the station had been broken up and the cairn removed. Mr. Stotesbury, however, set up the theodolite on a new station almost identical with the late Lieutenant Pollen's. The triangulation is based on the sides, Kausa-Tong—Lungleh, and Uiphum No. 4—Lungleh. A second station, Darbili No. 2 H. S., is also connected with Kausa-Tong, Lungleh and Uiphum No. 4. Several stations to the westward of the 1871-72 triangulation were also observed-to from Lungleh, Saipuya, Lungsin (on the return march) and Moisum; but no opportunities occurred of visiting any of them.

From the 10th to the 14th December Mr. Stotesbury and I were engaged in observing and working from Saipuya and Lungleh hill station, where we found the original cairn and mark. During this time I received much valuable assistance from Mr. C. S. Murray, the Political Officer, who gave me the names of peaks, villages, &c.

On the 15th I unfortunately had a sharp attack of fever, which I found hard to shake off, and which kept me in bed until the 23rd. After that, however, I rapidly got strong again and had no return of the fever. On the 24th, General Tregear and staff arrived at Lungleh, and we kept Christmas in the good old style, twenty-one of us sitting down to dinner at an improvised bamboo table in the police stockade.

The next two or three days were rainy and misty. On the 28th December a reconnaissance started from Lungleh to descend the Klong river as far as possible, with a view to select the nearer camps for the advance of the northern column on Lienpunga. Sub-surveyor Ikbaludin was detached with this party, as I had detailed him to accompany the northern column, when it started. The reconnaissance returned to Lungleh on the 4th January, having reached a point on the Klong river 23 miles north of Lungleh. Ikbaludin had sketched a fair amount of country and had gained an idea of what the country was like ahead.

On the 29th Mr. Stotesbury was down with fever and ague, which he did not shake off until the 20th January, being confined to his bed all that time and quite unfit to work.

On the 2nd January 1890 I marched out to Teriat (8 miles), the first camp on the Haka road from Lungleh, with Sub-surveyor Jamaluddin and 17 *khalásis*. Jamaluddin had started a compass and chain traverse of the new road from Lungleh on the 13th December, and he had orders to carry this work on, keeping up with the road as it advanced.

On the 3rd I proceeded to the top of Moisum with an escort of 5 police, and found the cairn of stones and original station mark. From there I observed with the 6-inch theodolite and started plane-tabling, cutting in some peaks to the south and east.

I went again next morning with a good supply of gun-cotton, which made short work of the large trees growing on the slopes just below, and thus cleared the whole of the bluff. That evening, on my return to camp, I found my escort of 25 police (for whom I had previously applied so as to enable me to camp out beyond Moisum) had arrived. The next day was very rainy, so I could do nothing, but on the 6th, early in the morning, I went up to the top of Teriat, hoping to be able to find a suitable spot on the summit for a station so as to connect with Moisum and Lungleh or Saipuya. I found the jungle so dense, however, and the trees so large, that I was forced to give it up, and about 11 o'clock after a good deal of clearing I managed to get a fixing on the east slope below the top, which gave me a fair view eastwards and north along the Klong valley. Clouds and mist rolled up about 3 P.M., and after waiting some time for a clearing, I was forced to return to camp.

On the 7th January, early in the morning, I started for a camp just south of Moisum, which had been occupied during the advance on Howsata's village the year before, and where there was said to be a small supply of water. I found this very scanty, but leaving the native officer to form the camp there, I went on to Bolpui with a small escort. When I arrived there about 1 P.M., I found the top, (which I was informed was *quite* clear) a tangled mass of reeds, grass, nettles, &c., completely shutting out the view on all sides. It took me some time to find the highest point in the dense undergrowth, and when I did find it I saw that it would be impossible to clear and do any work there that day. I accordingly moved down the eastern side of the hill, and after very hard work we managed to open out sufficient for a fixing. But all luck seemed against me that day; the distant peaks were all hidden, and from the south dense masses of fog and mist came rolling up, which quickly hid everything. The valleys of the Mat and Koladyne rivers were soon covered, so I had to give it up. On my way back I went to a clearing which had been made the year before, but not used, for signalling to the column advancing on Howsata. I waited there some time, but the mist did not lift in the slightest, and I was compelled reluctantly to return to my small camp under Moisum, which I reached just after sunset. Owing to a

mistake in the rations sent out I found I had only sufficient to last the next day. So I determined to start early for the signal station. The day was fine and very cold. I got a good fixing from some distant peaks which were standing out well, but was forced to leave the plane-table set there for a couple of hours or so, during which time the mists gradually cleared from off the valleys, and settled around the higher peaks, where they generally hung until 3 or 4 o'clock in the afternoon. I frequently had to adopt this course afterwards, *i.e.* get my fixing and take what rays I could to the higher peaks early in the morning, then leave the table set until 11 or 12, when the valleys would become clear and the peaks in their turn get hidden. From Bolpui I managed to cut in several villages and got in a fair amount of detail to the east. From there I marched back to Teriat camp, arriving at sunset.

The next two days I visited my stations on Teriat and Moisum, chiefly looking out for distant villages with the glass. I found several new ones far to the east of Malliam Pui, most of which I subsequently verified. I also tried a final charge of 10lb of gun-cotton on an enormous tree, which hid a good portion of the Klong valley from Moisum. After two unsuccessful attempts the charge detonated, and the report must have considerably disturbed the inhabitants of the villages for miles around. A large hole was blown clean through the tree, and though it continued to crack ominously all that afternoon, it refused to fall whilst I was there, much as I wanted it to. However, it fell during the night, as I saw with my glass next morning from Upper Klong camp.

I proceeded to this camp (the most advanced on the road, 11¾ miles from Lungleh) early next morning, and on proceeding to the heliograph station, found Captain Browne, the signaller, still clearing there. I made my men help, and towards noon we had made a good clearing. I found it hard to get a good fixing for some time, owing to the peaks being then hidden and the valleys clear. However, I succeeded eventually and got in a good deal of the Mat river valley.

Next morning I returned to Lungleh, where I found Mr. Stotesbury still down with fever. I received orders that day to accompany a reconnaissance, starting next morning from Lungleh, which was to visit Lalthuama's village, between the Mat and Koladyne, to punish him. We left Lungleh early next morning with 50 men of the 2-2nd Gurkhas and 50 Frontier Police and the following officers:—

Captain Browne, in command;
Mr. Murray, Political Officer;
Captain Hall, in command escort;
Captain Shakespeare, Intelligence Officer.

Before leaving I had handed over all the triangulation to Mr. Stotesbury, as I was informed by the General that there would be frequent reconnaissances of this sort, which he wished me to accompany. I had always to march light, so I determined to confine my work to plane-tabling and the selection and poling of stations for Mr. Stotesbury, whilst he had entire charge of the triangulation. I requested him when he was strong enough, to follow me to Moisum, &c., and I left my angle book with him. Mr. Stotesbury proceeded to Teriat camp on the 22nd January, and after observing from Moisum, &c., returned to Lungleh on the 26th. Thence he went northward on the 28th to Lalthonbunga's village and after sketching the country returned to Lungleh on 31st January.

The reconnoitring party marched on the 13th January as far as Upper Klong camp, 11¾ miles; on the 14th, to the eastern bank of the Mat river, 5 miles, and on the 15th to Lalthuama's villages, 8¼ miles, through the Lakir village. The chief, Lalthuama, was made a prisoner in the Lakir village and carried to his own, where a heavy fine was imposed on him. Part of the fine, in the shape of goats, pigs, fowls, &c., was paid at once. The goats and porkers were divided amongst the Gurkhas and followers, who seemed to relish them greatly.

Lalthuama's new village stands on a high cone, at a height of 3,300 feet above sea level, and is immediately over the Koladyne river, the level of which, as taken by Captains Mullaly and Hall, was 780 feet only above sea level. We halted all the 16th in the village, and I was able to do a good deal of plane-tabling. From Murray and his interpreters I also got a good deal of information regarding names of villages, hills, &c., and the courses of streams.

The next day we returned to the Mat river and occupied our old camp, taking our prisoner with us amidst the lamentations, loud and long, of all the villagers, who firmly believed they would never see him again. He was, however, only to be taken to Lungleh to remain there until the fine was paid up in full. The sight of our road and a little blasting which he saw opened his eyes considerably, and he is reported to have said that we were "Gods, not men."

On the 18th January we left the Mat river and separated, Captains Hall and Shakespeare returning to Lungleh direct, Browne and Murray to Teriat, whilst Mullaly went to the advanced camp 17 miles from Lungleh, and I to the 15-mile camp, where I worked, returning to Lungleh on the 20th, where I remained, inking in my work and making a tracing of it for the General. On the 25th the main body of the northern column left Lungleh under Colonel Skinner, 3rd Bengal Infantry. Sub-surveyor Ikbaludin with the 5-inch subtense theodolite, plane-table, 6 *khalássis*, and coolies, also left with orders to survey all the country he possibly could, and to return with the column to Calcutta *viâ* Changsil Bazar and Cachar.

On the 26th I again left Lungleh for the front, not intending to return. Mr. Stotes-

bury had returned from Moisum and Bolpui the same day, and after visiting Lalthonbunga's village on the north, was to proceed to the front. Next day I reached the Mat river camp, 20 miles from Lungleh, and remained there till the 29th. On the 30th I went out ahead of the road with Major Leach and Captain Mullaly, and obtaining a fixing, got in some of the valley below Lalthuama's village. On the 31st January and 1st February I visited a high cone, some 5 miles from our advanced camp on the Mat river (known as Bridge camp), 22½ miles from Lungleh, and from there, for the first time, saw the bend of the Koladyne river round Malliam Pui, and the valley of the Narchong nullah between Malliam Pui and the Darjow Klang.

On the 2nd February, a reconnaissance party, consisting of Captains Browne and Shakespeare, Mr. Walker, Telegraph Department, and 50 2-2nd Gurkhas, which I accompanied, left Bridge camp early for Darbili's village situated on an off-shoot of the Malliam Pui Klang, some 6 miles south of the highest peak (known as Lung Leng). Darbili is a queen, a rarity in these parts, a strong-minded old lady who has been uniformly friendly to us. This was a peaceful political mission, and I hoped, with the rays I already had on my board, to sketch in a good deal of country, nor was I disappointed, as the view from a point above the village (over 5,000 feet high) was magnificent, and from this point alone I sketched in about 150 square miles of country. We crossed the Koladyne on the 2nd after a long march from Bridge camp, and I was lucky enough to catch two mahseer, one of 8lb and the other well over 20lb weight; we had no scale. These were the first fish caught in the Koladyne during the two expeditions, and proved a welcome addition to the scanty fare in camp.

On the 3rd February we started up a spur of the Darjow Klang through dense bamboo jungle for the first 2 miles, and subsequently through very large tree jungle. Our rise was pretty stiff at first, but as we got up the hillside the Kuki path became easier. The ascent altogether was from 750 feet, the level of the Koladyne at the point we crossed it, to 5,100 feet, the height of Darbili's old village (the present site of Fort Tregear), where we cleared and formed our camp a mile and a half from the highest point of the Darjow Klang and north-west of it. Next morning (4th) at 6-30 A.M. we left camp, and after descending to the Narchong nullah (3,100 feet), distant 3 miles, we rose again to 5,100, the height of the point in Darbili's village, where I established a station for Mr. Stotesbury. Darbili's son, Lemboo, came out to meet us a mile from camp and gave us rice-beer to drink. The villagers were very friendly, bringing down fowls, eggs, sweet potatoes, &c., for sale, but their prices were exorbitant; nor did they know anything of the value of money; their standard being the rupee for everything, and as often as not, a small brass uniform button being a better bargain than a rupee. Our camp was formed about 100 feet below the village, and to the west of it. We remained at Darbili's all the 5th, and sending on the coolies to the Narchong nullah about 10 on the morning of the 6th, remained behind ourselves to allow Captain Shakespeare to perform the ceremony of swearing friendship with the Queen and her tribe. This ceremony consists in the slaughter of a *gayal* or *mithun*, both the parties assisting by the head representative of each, holding a spear, which is thrust into the *gayal's* heart. On this occasion no spear was forthcoming, so the beast was shot instead, and the usual custom of besmearing one another with its blood was dispensed with. There were a number of Lushais present at the ceremony, in fact, nearly all the inhabitants of Dopura's and Lalthuama's and Dokopa's villages. Soon after noon we left the village, every one seeming very friendly, and found our coolies and the majority of our escort forming camp near the Narchong.

On the 7th we marched back to our old camp on the Darjow. Browne endeavoured to open communication with Lungleh, which we could plainly see from a point above our camp, but was unsuccessful, whilst I also failed in trying to get a clearing made towards the east.

Whilst here we received a note from Shakespeare saying that Vantura, a chief occupying Howsata's old village, or at least a new village near the old site, was coming in with an armed retinue. We therefore returned to camp and found Shakespeare in conversation with the chief (a big powerful man, with an execrable squint, and unpleasant cast of features altogether), who had brought in the revolver taken from Lieutenant Stewart, when he was killed near the Belasuri Tong in February 1888. The chief was made a prisoner and his rabble turned out of camp by the Gurkhas. We expected they would make some attempt to rescue him, but we never saw or heard of them again, and reaching the Koladyne next day, we arrived at Bridge camp on the morning of the 9th and I found Mr. Stotesbury there. The next day I marched on to Lalthuama's camp, and on the 11th reached the Koladyne. Mr. Stotesbury joined me there on the 14th with Jamaluddin, who had brought the traverse of the road on to this point, 34½ miles from Lungleh.

On the 17th February I accompanied Captain Hall in a search for water, for an advanced camp some 7 miles east of the Koladyne, and on the Darjow Spur along which the road was then running. But we were unsuccessful. At this time I was arranging for a visit to the Purún Klang, two days' march north of the Koladyne camp, and as it is over 7,000 feet high I expected we should be able to do a good deal of work. I expected to start on the 23rd, but on the evening of the 21st I received orders to go to Darbilis' village again and keep open communication with a reconnoitring party under Captains Hall and Shakespeare, who were to advance eastward towards Tao and endeavour to effect a junction with General Symons's force. I obtained leave for Mr. Stotesbury to accompany me, and La Touche, of the Geological Survey, came too. I consider it a great pity that no survey officer was sent with this reconnaissance, as the help to the survey would have been great.

However, I remained at Darbili's from the 24th February, receiving and forwarding heliograph messages from Captain Hall's party, to Fort Tregear (then in course of construction) until the 4th March. On that date I received orders to proceed alone to Dopura's village, leaving La Touche in charge at Darbili's, with Mr. Stotesbury and 20 police.

At Dopura's I found 200 of the 4th Gurkhas under Captain Drury and Lieutenant Grant, who had just marched in, and in the evening we were joined by Major Leach and Captain Mullaly, R.E. It was intended that I should have gone on with Major Leach next day to Sangao, a village 9 or 10 miles off, and probably our next camp; but having been badly stung by hornets that evening, I was obliged to remain in camp. I worked in the vicinity of Dopura's village the next two days, visiting a solitary cone on the second day, some 3 miles south-west of the village, which overlooked the Darjow nullah and the northern spurs of the Blue Mountain. On the 8th I moved camp with Mullaly to Sangao.

On the 9th March Mr. Stotesbury returned from Darbili's to Fort Tregear to observe from a new station, kindly made for us there by Major Leach, R.E. I found an excellent point above our camp at Sangao, which I had previously fixed. It was quite bare, some 4,900 feet elevation, and from it one saw all the bed of the eastern bend of the Koladyne, the Chirian and Tao Klang, and the south-east spurs from the Blue Mountain. On the 11th Hall and Shakespeare returned from Haka and proceeded next day to Fort Tregear, giving us a very pleasant picture of the country east of the Tao, with visions of open grassy downs, pine trees, rhododendrons in full bloom, oranges, and all manner of fruits. On the 13th I went down to the Koladyne with Major Leach, looking out for the trace for the road. We got caught in heavy rain, and it rained pretty well incessantly for the next five days. However, during a break on the 16th, I managed to move camp to Koladyne No. 2. It was too wet to do any work for some days afterwards; the river had risen some 6 feet, and there was no crossing until rafts were made. On the 21st I made a small clearing above camp on the ridge and got in what I had long wanted, *viz.* the junction of the Tipi and Koladyne. On the 22nd Mr. Stotesbury came in, having observed from Fort Tregear and Sangao (two stations): the rain had also greatly impeded his work. On the 24th I accompanied Major Leach across the Koladyne and Saisi and along the ridge between the latter nullah and the Shertok river. That evening on returning to camp I received a telegram from Renny-Tailyour, dated from Haka, requesting me to meet him on the top of the Tao Klang on 27th March. He was evidently coming with the coolies, being sent by General Symons to take the kits, &c. of the 4th Gurkhas from Tao village to Haka, up to which former point they were to be carried by Sonthali coolies from our column. I accordingly left the Koladyne on the morning of the 26th, picking up 40 Gurkhas and 48 coolies at an advanced camp 4 miles from the Koladyne. I hoped to reach Tao village that evening, but the march was too much for the Sonthalis. I was therefore obliged to halt for the night in the Pullook nullah, 2¼ miles from the village and 2,000 feet below it. We reached Tao village about 8 A.M., on the morning of the 27th, and having come without warning, found the villagers in a great state of alarm. However, they quieted down after a time and we occupied the camp originally made by Captains Hall and Shakespeare when they met General Symons's reconnoitring party under Captain Rundall. Renny-Tailyour, Hildebrand, and the Naga and Khasia coolies for the 4th Gurkhas arrived in camp about 2 P.M., whilst Mr. Stotesbury and I were working from a clear point above the village. Some of the 4th Gurkhas came in that evening, but the majority did not arrive till next day; so, early on the 28th Renny-Tailyour, Mr. Stotesbury and I with 30 Gurkhas and 20 Khasia coolies with axes, gun-cotton, &c., started for the top of the Tao Klang. We arrived there about 11 A.M., and commenced clearing through very thick *ringall* or short bamboo. I tried a gun-cotton charge on a large tree, but unluckily the fuze was bad, and I did not get off a charge all day. However, with axes we managed to clear sufficient. The day was a wretched one for distant work: a thick blue haze hung over every hill and fairly well hid the valleys. However, we commenced the connection of the two sets of triangulation, and subsequently at Tlang-Tlang and Haka hill stations, the same stations were used and observed from by both parties and connected westwards by Mr. Stotesbury. I secured a good deal of topography from Tao hill station. We reached camp about 5-30 P.M.

I determined to accompany Renny-Tailyour and the 4th Gurkhas to Haka next day, and accordingly took four *khalásis* and five of the best of my coolies. I directed Mr. Stotesbury to return with the coolies and forward them to the most advanced camp on the road, then running along under the Chirian Klang on the left bank of the Shertok. An average rate of 11 miles a day brought us to Haka on the 1st April. I managed to get four or five fixings every day on or near the road, and thus carried a good strip of topography on each side of the road into Haka. General Symons received us very kindly, having a good breakfast ready for us on our arrival. On the 3rd I went up to Renny-Tailyour's station on the Rong Klang above Haka with my plane-table and completed the topography near Haka. On the 2nd, hearing that General Symons was to start on the 5th for a reconnaissance southwards from Haka along the Boinu river, I wired to General Tregear for leave to accompany General Symons, and on the 3rd obtained it. The reconnaissance left Haka at 6 A.M., on the 5th April and marched southwards the first day, keeping along the Boinu-var as far as the village of Bwonlon (height 5,250 feet), 16 miles from Haka. I managed to keep up with my plane-tabling, using chiefly some points given me by Renny-Tailyour. On the 6th we marched to Doong-Var village (height 5,450 feet), 9 miles from Bwonlon. Renny-Tailyour established a station here 3 to 4 miles from the village and just above the Boinu, and observed from it, whilst I plane-tabled. We reached camp about 3 P.M.

We started at 5-30 the next morning from Doong-var, and leaving the Boinu marched westwards up a spur of the Yo-vai-lung Klang, reaching the summit (8,100 feet) at

7-30 A.M. This is the highest point that was reached by either of the two columns during the expedition. Renny-Tailyour and I determined to wait here, though the day was far from promising. It was damp and very cold, and a heavy mist and fog was rolling up from westward, completely shutting out everything, even the nearer valleys. There were occasional breaks, but the mist did not lift until 10-30 A.M. Even then it was by no means a clear day, especially to the westward, where there was a thick haze and where heavy clouds were forming, which looked like rain. However, we worked away until 12-30, when, not knowing how far the General was going, we determind to close work and march after him. From this point we could see the valley of the Boinu very clearly below us, and we traced its course as it gradually turned to the eastward, and when we last saw it, it was flowing almost due south-east, round a long spur from the Yo-vai-lung range, on which I had fixed two peaks. The view from this point on a clear day must be superb, particularly towards the east and west, the high masses of the great Yo-vai-lung range shutting out the view to the north and south.

We descended the ridge pretty sharply to the west, and passing through the village of Lai-tet, turned due south, the path running some 2,000 to 3,000 feet above the valley in which the Tang-horr var was running south towards its junction with the Boinu. We reached camp shortly after 5 P.M., near the village of Aibur (height 5,250 feet), after a stiffish march of 14 miles from Doong-var village, the ascents and descents having been considerable all along the road.

Starting before 5-30 next morning, our road still ran due south and parallel with the Tang-horr. We dipped down and crossed the Tiar-te var (which runs into the Tang-horr), and for the next 10 miles we went along a long ridge with no water until we reached the village of Naring, height 4,750 feet, a total march of 17 miles from Aibur. We had here considerable difficulty about water, but at last Ross found some in a nullah, about half mile from the village, and at a height of 4,300 feet. We made our camp near this water and the General determined to halt a day here. Next morning Renny-Tailyour and I, accompanied by Ross, went back along our road to a high point on the ridge, about 2 miles north of the village, which we cleared and made a station there.

Below us we could see the Boinu, now greatly enlarged and not much inferior in size to what the same river is at our second Koladyne camp. We could trace the river flowing north-west and rounding the end of the ridge on which we then were. We then saw it still flowing north-west for some miles below us, before it bends due south and rounds the high Shah-mun Klang. It flows at the foot of this rugged range (the highest peaks of which must be 9,000 or 10,000 feet high), and curving round its southern slopes in approximate latitude 22°7′30″, longitude 93°22′, it resumes its north-west course, receiving the La-aw var and the Tipi before it bends west around the Malliam Pui Klang. Here it receives the Tui-Pui from the northward, then bending south, the Mat joins it north-west of the Blue Mountain, and it continues its course southwards to the sea. The villagers near the Blue Mountain assert that two or three days' journey from that neighbourhood, the big river enters a 'rocky house' (tunnel or cañon ?), and that it flows through this for a considerable distance, which effectually puts a stop to its navigation. This may be true or a myth, but it seems hardly probable that so large a river as the Koladyne can be completely shut in. Most probably a deep rocky gorge which confines the river, causing strong rapids, is here meant.

At Naring, the Boinu is called the Boinŏ and after the Tang-horr var has joined it, the stream is known as the Tipi (or great water). It is known thus (or by the equivalent Tui-Pui) all along its course, nor do I know where it first receives the name Koladyne or Kaladan. This name Tipi or Tui-Pui is very unsatisfactory. As I have mentioned, it simply means 'great water,' and yet there is a Tui-Pui flowing south between the Til and Aitur Klang, a Tipi flowing south between the Doong Klang and Bual Pui, and both of them flow into a river which itself is known as the Tipi or Tui-Pui.

The height of the Boinu, when crossed 6 miles west of Haka on the Tao-Haka road, is nearly 5,000 feet; due west of the village of Naring it is 2,200. At the second Koladyne camp it is 1,250, and at the first Koladyne camp 820 feet. There are said to be very large rapids, where it rounds the Malliam Pui Klang, and from the above figures it would seem very probable.

From the testimony of all the villagers through whose villages we passed between Haka and Naring, there seems to be but little doubt that the Boinu, as last seen from the Yo-vai-lung above Doong-var village, and the Boinŏ, as met again below Naring, is one and the same river.

As the crow flies it is only 12 miles between the points where we left it and met it again. Yet it is said to be nearly 90 miles round the bend. The names of the villages met on this road round the bend were given us, and the accounts of the marches between the villages and the positions of the villages themselves, with their names, agreed very well, as given by the different informants. So it may perhaps be taken as settled that the main, or at least one of the main sources of the Koladyne river, is the Boinu, rising a few miles north-west of Haka.

On the 10th April we left Naring and retracing our steps along the road we had come for some 7 miles, we eventually turned north-west along a long spur ending in a sharp cone around which the Tang-horr var makes a sharp bend, and on the north-east side of which the Tiar-te var flows till it joins the Tang-horr. After a long march of 17 miles, the last four of which were along the bed of the Tang-horr, with incessant crossing and re-crossing through water up to the hips, camp was formed in the Tang-horr valley near the river, close to the junction of the Hlampi var. The height of the Tang-horr, when first met below the

cone was 2,550 feet. On 11th April we had a steady pull up-hill of 7½ miles to Kabon village, situated just on the west side of a high range, with precipitous peaks, which runs north-north-east and north, past Hripi village and juts into a branch of the La-aw.

Renny-Tailyour and I worked from a small cone above the village at a height of 6,000 feet from whence we got a good view. I had had fever the night before, and it stuck to me for the next three days, rendering the hard marching anything but pleasant. On the 12th April, we kept along the side of the slope, crossing a large number of small streams flowing west until we entered the valley of the Pai-var, at the head of which was the village of Ye-pai. This valley was very pleasant, being quite open with green grass fairly flat and varying in width from one-quarter to three-quarters of a mile. We passed through Ye-pai and just beyond it, Renny-Tailyour cleared a station and observed. From here we got our first view of the Blue Mountain during this reconnaissance. There was a grand view from this point, and the day was fairly clear. Our road still lay to the north, and after passing through Wantu village (about 4,000 feet), we reached camp, which had been formed three-quarters of a mile from the village, north of it, on the Nuit-var (height 2,500 feet); length of march 13½ miles. Next morning we started very early (about day-break), knowing that we had some stiffish climbing to do. It proved to be the case, and we had one very difficult bit, through a ready cut *jhúm*, which was shortly to be burnt. This was nothing but a mass of large fallen trees with tangled branches, completely blocking the road, and the continued scrambling in and out proved very trying. Reaching the summit, we ran east along the northern slopes of the range. A fixing on this slope gave a good deal of the La-aw var valley, and also of the country to the west. We shortly emerged on another wide open valley, well watered by a stream which flows westward into the La-aw. We were now on the southern route from the west to Haka.

Starting from Sangao village west of Koladyne No. 2, the northern route goes up the bed of the Saisi nullah, crosses the Shertok and Pullook, and so into Tao village. It then ascends the Tao Klang (north east) and crosses the ridge a mile and a half south-east of the highest peak at an elevation of over 6,000 feet. Thence descending eastwards, it follows a long spur, past the site of old Hmun-Lipi village to new Hmun-Lipi and running south-east, it crosses the Tidi and La-aw streams and the Kyu-Klang range (6,100 feet) and then descends to Tlwa-lam village. From Tlwa-lam it crosses the Wiship range and, passing just north of Tlang-Tlang villages, it crosses the Surang Pulang Klang, descends to the Sa river which it crosses and recrosses 13 times and then meets the Boinu 6 miles from Haka, and so runs due east into Haka.

The southern route from Sangao goes south and descends to the Koladyne, then through the villages of Ainat, Vam-kwa, Hripi, Saungtia and Kusa runs south of Pupi hill, and crossing the Boinu 3 or 4 miles south of where the northern road crosses it, runs north-east into Haka. This southern road is said to be more difficult than the northern one: where we traversed it from Hripi to Haka it certainly was not bad, the difficult part must be between Vam-kwa and Hripi, through the valley of the La-aw, which is very precipitous. We reached Hripi fairly early in the day.

On the 14th April, we marched from Hripi due east over a fairly high range, then descended and went along the watershed between the Tang-horr and La-aw tributaries, through Saungtia village to Kusa village, which is situated on a northern spur of the Yo-bai-lung range; march 12½ miles. On the 15th we marched from Kusa village, round the southern side of Pupi hill, and descending to the Boinu, halted there an hour, and thence into Haka. Ponies had been sent out to meet us from Haka, and I rode in the last 2 miles; the first time I had ridden on the expedition. This march was 16½ miles, and we arrived before 1 P.M., at Haka.

We found that General Tregear was returning the next day to Fort Tregear, so there was but little rest. Mr. Stotesbury had carried the triangulation into Haka and had visited Renny-Tailyour's station there and observed from it. We left Haka on the 16th April and from that date we marched back westwards continually without a day's halt, starting off with a 20-mile march to Tlang-Tlang. Our work was now practically finished, but on our way back we visited the stations on the Soorang-Pulang-klang, Kyu-klang, Hriankan, and Sangao-Klang. We had rain every day or night from the 16th to the 23rd, the day we arrived at Fort Tregear. We left Fort Tregear on the morning of the 24th and reached Lungleh on the 27th. Mr. Stotesbury observed from Lungleh and Saipuya stations on the 28th, on which day we left for Lower Lungleh, arriving at Demagiri on the 2nd May.

At Demagiri I handed over to the commissariat the remnant of the 40 coolies, of whom 13 had been invalided. We left Demagiri at 5 A.M., on the 3rd in boats, reaching Rangamati at 8 A.M. next morning. We left Rangamati at 7 A.M. on the 5th, arriving at Chittagong that evening and embarking on the Indian Marine steamer "*Clive*" early on the 7th, reached Calcutta at 5 P.M., on the 9th. In all we were 24 days from Haka to Calcutta.

General Remarks.

The country passed through, as far as the 2nd Koladyne camp, is simply a mass of greatly broken up hills, with steep sides, the whole face of the country clothed with dense jungle, the hills rising to 5,000 or 5,500 feet, the valleys very low and narrow. The descriptions in the reports of Colonel Woodthorpe, C.B., R.E., and of Colonel Tanner, apply precisely to all this tract of country, so repetition would be useless.

Proceeding eastward, however, from the Koladyne over the Tao Klang, the nature and aspect of the country undergo an entire change. One no longer meets with the dense undergrowth of the western districts, the features are larger and bolder, and the face of the

country is not so broken up. The hillsides, as a rule, are covered with grass, and the pine, oak, and rhododendron take the place of the massive jungle trees and thick bamboos of the country to the west. From Tao, eastwards, too, the nature of the villages changes. Sangao is the last bamboo village met with, Mapoya's, on Tao Klang, being a permanent village built of timber logs roughly dressed, with floors and sides either of planks or roughly squared balks. The houses too are larger, and level places are dug out of the side of the hill for them.

The inhabitants, however, seemed the same all the way through from Lungleh to Haka and down south and south-west of Haka. Though called 'Chins' by the Chin column, to me they seemed precisely similar in type of features and dress to the Kukis or Lushais of Saipuya's or Lalthuama's villages. There were differences however in the language. The Haka people just knew Darbili by name, but had not heard (or professed not to have heard) of any villages or chiefs west of that. They said they were afraid of the Malliam Puis, as they bewitched them and practised the evil eye on them, &c., &c.

All the men seemed to possess some sort of a gun each, mostly old Tower muskets. Guns were especially numerous south of Haka, and there was a continual popping to be heard from camp there, the young men being always on the look-out for *shikar* of some sort. There is undoubtedly game in all these jungles, but as elsewhere in thick undergrowth, it is next to impossible to stalk them successfully, though occasionally *sambur* and *kakur* and pig were shot by some of the frontier police. There are a large number of different sorts of pheasant, partridge, and snipe round Haka, also woodcock. A good number of mahseer, up to 28lb in weight, were caught in the Mat and Koladyne, and these rivers must evidently be full of fish running up to great weight. Rhinoceros are occasionally met with. One, I believe, caused much sensation by walking into (or trying to do so) the General's cook-house at Fort Tregear. Another came and looked at some coolies at work on the road, who promptly fled.

Nomenclature.

There was a great difficulty experienced on both sides in finding out the correct names of hills, villages, streams, &c. As a rule, the same river or hill is known by entirely different names, by two villages only a few miles apart. For instance, take the peak marked as Sangal Klang in the 1871-72 map. This is undoubtedly called 'Sangao Klang' by the Howlongs, living north and north-east of Lungleh, and by Saipuya's and Lall Ruma's villagers: the Malliam Pui name for the same peak is Tao-Klang; whilst to them Sangao is the Blue Mountain, and this obtains all the way south-west of Haka. The people of Ye-pai village, pointing out a large village due west of us on a spur from the Blue Mountain, call it Shangao, and they also name the whole mass of the mountain 'Shangao.' I have before remarked on the Tipi and Tui-Pui.

Another peculiarity is that from Tao village eastwards, all the villages are known by a geographical name, whereas west of Tao the villages are named after the headman or chief. Probably this is due to the temporary nature of the villages to the west and permanence of those to the east. By the Chin column, a Burmese spelling and pronunciation was given to most of the Lushai villages, hills, and rivers east of the Tao. This, I think, is rather a pity, the Lushais (or Chins) having little in common with the Burmese in any respect. For instance, it was decided to call the large range south-west of Haka in the bend of the Boinu the Yo-vailung, though it is undoubtedly pronounced by the Lushais as Zo-vailung.

Final results of survey and details of work done.

The triangulation was of necessity only run eastwards, and a good deal of difficulty was experienced in carrying a chain of triangles right through to Haka. The only station off the road was Tao station, which was visited; but the day was a wretched one for observation. Being limited to time the station was not revisited. Tlang-Tlang and Haka stations were fixed by Lieutenant Renny-Tailyour and were used by me, and connected to my stations westwards. Altogether 18 stations were observed from. It is impossible to say at present how many intersected points have been fixed, but more than 50 may be depended on, though nearly 100 have been observed-to and will probably be secured. The heights of nearly all points observed-to have been taken, and double values to over 75 per cent. of them.

An area of nearly 6,000 square miles of topography has been completed on the $\frac{1}{4}$-inch scale. More would have been obtained could a visit have been paid to the Purun Klang, and had the weather been less hazy during General Symons's reconnaissance south-west of Haka.

A compass and chain traverse has been run from Fort Lungleh into Haka along the new road, and posts were erected by the survey party at every quarter mile up to mile 45, which is ten miles beyond Fort Tregear.

Demagiri, Fort Lungleh, and Fort Tregear have been surveyed, the two former on a scale of 12 inches to the mile, and the latter on a scale of 100 feet to the inch.

My thanks are due to Major Leach, R.E., for the assistance I frequently received from him in many ways. Also to C. S. Murray, Esq., the Political Officer, from whom at Lungleh I received much valuable help in the way of nomenclature, &c., and who took much trouble in December in obtaining information regarding the country, which was of the greatest use to me.

In conclusion, I have the honour to report most highly on the services of Mr. W. Stotesbury, Surveyor, 3rd grade. He ably maintained his reputation of being a skilled observer and first-rate draftsman. He worked zealously and willingly throughout, and in spite of the

difficulties to be overcome in the way of hazy weather, dense jungle, and severe marching, he carried out the triangulation most efficiently, and I can only regret that we had not greater opportunities of moving off the road.

From reports received from officers of the northern column I hear that Sub-surveyor Ikbaludin was most energetic and hard-working, and accompanied all the reconnaissances from the main body. Sub-surveyor Jamaluddin kept his road traverse well up to date throughout, and worked especially hard when the road was being rapidly pushed forward from the Koladyne into Haka.

CHIN HILLS.

Report on the Survey Operations with the BURMA COLUMN, CHIN-LUSHAI EXPEDITIONARY FORCE, *by* LIEUTENANT T. F. B. RENNY-TAILYOUR, R.E.—*Season 1889-90.*

The party under my charge consisted of Sub-surveyors Bapu Jadu and Ali Nawaz Khan with fifteen *khalásis*. We started from Rangoon on the 10th November 1889 and reached Pakokku on the 13th. All the troops for our column were concentrated at Pakokku and then marched in detachments up to Kan, the base of the operations. The distance from Pakokku to Kan was about 170 miles; carts could be taken as far as Tilin, after which place pack animals had to be employed.

At Pakokku all superfluous baggage had to be left behind, the regulation allowance being only 60lb for an officer, 25lb for a surveyor and 15lb for a *khalási*; no tents were taken, but a small allowance was given for office requirements. These allowances were exceedingly small, considering we were going to be away for about six months in a hilly country, with considerable changes of temperature. Luckily, I was generally able to make private arrangements for carrying a little extra baggage.

We left Pakokku on the 19th November with the first detachment of troops, and arrived at Pauk on the 22nd, where we halted a day, part of the troops not getting in until the afternoon of the 23rd; the Yaw river just before Pauk was flooded, and everything had to be carried across on two elephants, which was a slow business.

The country up to Pauk is fairly flat, but soon after leaving Pauk some ranges of hills have to be crossed, and owing to rain the road was almost impassable for our carts and caused considerable work and some delay.

As there was some doubt as to the correctness of the existing surveys between Pauk and Kan, I told off Ali Nawaz to make a road traverse, and Bapu Jadu to plane-table, while I attempted to carry on a triangulation. Unfortunately it rained a great deal and most of the country was also covered with dense jungle and very little plane-tabling or triangulation could be done.

We reached Tilin on the 30th November, and from there to Kan the road was fairly level down the Maw and Myittha valleys. The day we marched into Gangaw I went up a very peculiarly shaped hill called Nattaung; the ascent near the top was difficult, owing to the rocks being very precipitous. On reaching the top we saw very little; all the important hill tops were in clouds, as they had been nearly the whole time since we left Pauk. Our guides here told us that the short path to Gangaw, which they had spoken about the night before, did not exist, and we were obliged to go back nearly all the way to our old camp before we started on the Gangaw road; we got into Gangaw about 9 P.M., after about 30 miles walking. We did not feel inclined to let our guides off easily, and made them come the whole way with us and help to carry the instruments, &c. We eventually reached Kan on the 6th December. During the next week all the troops arrived from Pakokku, coming in detachments of from two to three hundred daily.

At Kan there was a large clearing with paddy fields, but as the paddy had not yet been cut, I was unable to measure a long base line then, and had to content myself with a small temporary base. I observed at Kan for azimuth, latitude, &c., and also went out for a couple of days to a small hill to the east, which I had cleared and made into a station of observation. The position of Nattaung was supposed to have been already fixed by triangulation, but from my observations I found that it was wrong and I was, therefore, obliged to take my observed latitude at Kan, and assume a longitude until I could connect my work with the Chittagong triangulation.

As there were no existing mule tracks from Kan into the Chin hills, our transport at the front had to be restricted to coolies. The coolies were Nagas and Khasias and were first-rate carriers. Each coolie carried 60lb besides his own kit, and used to get into camp very shortly after the troops, which was wonderfully good going, considering that some of our marches were over 15 miles and sometimes ascending and descending as much as 10,000 feet in the day. The coolies were a great contrast to the survey *khalásis*, as the latter seemed quite unfitted for this hill work. The *khalásis* with very light loads, probably not one-third of the coolies' loads, were often hardly able to keep pace with the coolies. The Nagas, and especially the Khasias, were also much better men for clearing hills, &c.

No arrangement had been made beforehand about transport for the survey party, and as the number of coolies available was less than had been expected, I was only provided with 10 coolies. The 10 coolies were only just sufficient for carrying all the baggage of my party, and for carrying our rations we were supposed to get extra transport, when required, if available. From Kan to Haka I generally had to move in two sections, half the party and some rations moving on a stage or two and then sending back our coolies to bring up the second half of the party with their rations. Eight days' rations alone amounted to the 10 coolies' loads. I was unable to take my interpreter beyond Kan, and we were also not supposed to take our ponies on. Owing to the limited number of coolies with our column, we were unable to go very far from our mule transport, and consequently

had to make a mule path to Haka as we advanced, which caused our rate of progression to be very slow.

We left Kan for the front on the 16th December. For the first few miles out of Kan the road passed over a fairly level bit of country, then crossed the Kabè range and dropped into the valley of the Laungat Chaung; this stream is small in the dry season, but said to be quite impassable during the rains. The road went up the valley for about nine miles to Chaungkwa camp, crossing and recrossing the stream over 40 times. From Chaungkwa the road ascended steadily to Taungtek hill, and thence on along a ridge to the Torsong range, and with a slight descent into Rawvan village; this was the first village met with, and is about 35 miles from Kan. From Rawvan to Haka, the road continuously ascends or descends and crosses a high range over 7,000 feet just before reaching Haka, and a range of 5,000 feet just before Yokwa.

We arrived at Rawvan on the 12th January 1890, and took up our quarters in the village. The houses are large with wooden floors and very good thatched roofs; the walls are generally planked and the house is divided into two rooms, the back room being very dark and used by the women, while the men sleep in the front room. These houses take the Chins a considerable time to build and are very substantial compared with a Burman's house. The walls of the houses are covered with all kinds of skulls, horns, &c., from an elephant's to a monkey's, according to the importance of the owner. The houses are usually enclosed by a paling, the dead being buried inside the enclosure, except in the case of a man killed by enemies or by accident, who is then buried outside the village, otherwise it would be considered unlucky.

The Chins are a very dirty race, and never appear to wash, the dirt lying on them in layers. The chiefs are distinguished by wearing plumes in their hair, but otherwise seem much the same as the rest of the people. Every little incident in a man's life is made the excuse for a feast and a drink; in fact, the people seem to be more often drunk than sober. The women are perpetually smoking pipes with a receptacle for catching the juice, which the men drink, and say it is most sustaining while on the march; each man generally carries a small flask of this juice and offers some to any friend he may meet.

Between Kan and Rawvan I made stations on Kabè, Taungtek and Torsong hills, but the weather was very cloudy and I never obtained a really good view from any of the stations.

The Chins several times fired a few shots into the camp at Taungtek, killing one havildar; one morning they got a bit braver, and actually attacked the camp, but were easily driven off and were followed up for some miles. There were several hundreds of them engaged in this battle, as they called it, and although none of them were touched, they said they had received a severe defeat and would give in to us; and after this the Yokwa and Haka tribes never seriously thought of fighting us. The pluck and fighting qualities of those Chins had been very much overrated, and they turned out to be not a bit braver than Burmans. At Rawvan the chiefs began to come in to us and acknowledge our authority, but it was some time before we managed to get them to bring in their slaves, and in some cases great pressure had to be brought to bear on them.

On the 13th two Chins in ambush along the road between Taungtek and Rawvan fired at and killed an officer who was passing. As the chiefs of the tribe to which these men belonged had not then submitted, we could not claim to have the two men given up for murder; but a village was burnt and a fine inflicted as a punishment.

We arrived at Yokwa, the capital of a large tribe, on the 18th January, and the principal chiefs came out to meet us.

Up to Yokwa the force had suffered most severely from fever of a very malarious description. I myself had fever almost daily from the 3rd to the 20th January; but after this the fever cases began to diminish, probably owing to the elevation we had reached, or, perhaps it was a case of the survival of the fittest.

On the 29th a small party was sent from Yokwa to reconnoitre for a new road to Gangaw. I accompanied this party, taking Bapu Jadu; we found that the line of road was not as good as the road from Kan to Yokwa and that there was a great scarcity of water; one day we had to march over 17 miles, and even then only found two small pools of water. The trip was not altogether profitless, as we made an addition to the map. On the 12th February we returned to Yokwa, having gone back by Kan, at which place I was able to measure a proper base, the paddy being all cut; I also visited all my old stations on the road up. We eventually arrived at Haka, nearly 65 miles from Kan, on the 18th February, and were agreeably surprised to find the country in its vicinity consist of grassy downs, and totally different to the steep hills we had been crossing. Our camp, and the site of the subsequent fort, were at an elevation of over 6,000 feet. From Haka a good view was obtained to the west, and a fixed point in the Chittagong triangulation called Tao Klang (formerly erroneously called "Sangal Klang") was seen. During the first few days at Haka, I was busy making stations, observing, &c., and by means of Tao hill, I was able to connect my work on to the Chittagong triangulation and correct all my former work accordingly.

On the 26th February, with Bapu Jadu, I accompanied the reconnaissance to Tashon, having on the 23rd sent off Ali Nawaz with a party that was going to connect with the Chittagong column. On our reconnaissance we got to within 6 miles of Tashon, and found all the villagers *en route* very friendly. We returned to Haka on the 1st March. On the 3rd the party with whom I had sent Ali Nawaz returned; they had gone as far as Tao and there met a small party from the Chittagong column, who returned to Haka with our party. On the return to Haka they managed to get the skulls and some of the accoutre-

ments of Lieutenant Stewart and the two soldiers who had been murdered on the Chittagong frontier in 1888.

On the 9th March, with Bapu Jadu and Ali Nawaz, I accompanied the expedition to Tashon, arriving there on the 11th. All round Tashon the Chins had erected numerous stockades, many of which had only been built within a week or two of our arrival; the reason we met with no opposition was probably due to the strength of our column, which contained over 400 fighting men and 2 mountain battery guns, and also because on the same day a column of nearly equal strength arrived within 6 miles of Tashon from Fort White.

On arriving at Tashon we sent for the chiefs, who came in more or less drunk, and although they had allowed us to come through their fortifications without resistance, now said they would not consent to our terms. This was rather an awkward position and they were sent away, and warned that they had better change their minds, or it would be the worse for them. That evening and the next day they had great meetings amongst themselves, and finally the peace party gained the day, and they decided to submit to all our terms.

On the 13th March I went with Bapu Jadu to the camp of the Fort White column, and although they were within six miles, we had to descend about 3,500 feet, cross the Nankathè river and ascend about the same height on the opposite side. The Nankathè, where we crossed it, has an elevation of about 1,300 feet, and is crossed at a ford, fairly deep at the best of times and, of course, quite impassable after heavy rain. The banks are very rocky and precipitous. The next morning I went up a hill behind the camp and did some surveying, returning to our camp at Tashon in the evening; the Nankathè river was beginning to rise and we were only just able to cross. I formed a station near Tashon and had also another between there and Haka, and from these two stations observed several points near Fort White fixed by the Burma triangulation. On the 16th March a small party was sent down from Tashon to Sehaung, and I told off Bapu Jadu to accompany it. Rain commenced to fall on the 13th and kept on with small intervals until the 18th, on which day we got back to Haka. We all had a miserable time of it during the rain, as our shelter consisted only of branches of trees which kept out very little rain; most of the column were more or less wet through the whole six days.

On the 23rd March I started off with Ali Nawaz and a large number of coolies who were going to Tao to bring in the baggage of the half Goorkha regiment, which was to garrison Haka during the rains. I formed a station on the road out, and at Tao met Lieutenant Bythell, R.E., and Mr. Stotesbury, who were doing the survey work with the Chittagong column. We partially cleared Tao hill and formed a station there. Bythell returned with me to Haka, which place we reached on the 1st April. Bapu Jadu had returned to Haka in the meantime, and I sent him off again with a small party, who were going down to Myintha. These two last trips of Bapu Jadu's were very useful in filling up a gap on our map.

There had been great doubts as to the source of the Koladyne river, and as the Chins informed us that a small stream called the Boinuvar, flowing within six miles of Haka, eventually became the Koladyne, General Symons determined on a ten days' trip to ascertain this fact; he also wished to visit several villages along the route. Bythell obtained leave to accompany the expedition, and I took Ali Nawaz. We had several severe marches, and in the 10 days covered 130 miles, which, considering the very hilly nature of the country passed over, was very trying marching. Bythell and Ali Nawaz plane-tabled, and I tried to keep up the triangulation, but the long marches, coupled with hazy weather, made good connections impossible. We, however, satisfied ourselves that the Boinuvar was the source of the Koladyne river, and added a good amount of new country to the map. We returned to Haka on the 15th April, and on the following day Bythell left with some of the Chittagong column, who had come in while we were on the Boinu trip.

This was practically the end of the expedition, and all the troops, &c., except the regular Haka garrison, were hurried down as quickly as possible. From what we had then seen, Haka appeared to be a most healthy place, with a nice climate.

I left Haka on the 20th April, reached Kan on the 26th and Kalewa on the 4th May. On the way down I observed from some of my old points, and had the Myittha river from Kan to Kalemyo accurately surveyed. During the expedition the survey party had, considering the very large amount of sickness amongst the troops, kept wonderfully fit; only 3 *khalásis* had to be sent down. Most of us, however, got fever again afterwards, probably brought on by our march down the Myittha valley.

The survey party had, during this expedition, mapped about 3,000 square miles of new country, and as there was always at least one of the sub-surveyors with every expedition sent out, no chance was missed of getting in new ground. Triangulation was also carried on over the area mapped, and a fair number of distant peaks fixed. The highest station observed at was over 8,200 feet and the highest peak about 9,000 feet.

The sub-surveyors both did very good work, especially Bapu Jadu, who displayed the utmost energy and zeal.

The country passed over was particularly void of minerals. There must be a tolerable amount of large game among the hills and in the *terai* in the Myittha valley judging from the number of heads and skins of elephants, tigers, leopards, bears, bison, pig, deer, &c., that we saw in the villages. There is also a fair amount of small game, and near Haka, among other birds a new description of pheasant, as well as several wood-cock, were shot.

I must record my best thanks to General Symons, commanding the expedition, to his staff, and to Mr. G. Ross, the Political Officer, for the ready help and great kindness which I at all times received from them.

DRAWING OFFICE, CALCUTTA.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILATION.

Statement showing the work performed during the year 1889-90.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
Atlas of India.			
Sheets Nos. 9 S. E., 21 N. E., 25 S. E., 26 N. E., 26 S. E., 38 N. W., 40 S. W., 40 S. E., 42 N. E., 48 N. E., 48 N. W., 68 N. E., and 78 S. W.	13	4	Additions to names and outline for engraving.
Sheets Nos. 39 N. E., 42 S. E., 48 N. E., 78 N. E.	4	4	Hills brush-shaded for engraving.
Sheets Nos. 10 S. W., 13 N. E., 13 N. W., 13 S. E., 20 N. E., 34 N. W., 34 S. W., 35 S. W., 40 N. W., 40 S. W., 42 S. E., 43 N. E., 60 N. W., 60 N. E., 60 S. E., 61 N. W., 61 N. E., 67 S. E., 78 S. W., 91 N. E., 91 S. W., 121 S. W., and 131 S.W.	23	4	Additions to railways, canals, and changes in boundaries.
Sheets Nos. 48, 112, and 114	3	4	Ditto ditto ditto.
General Maps.			
India. (Engraved)	6	32	Additions to date.
Do. do.	4	64	Revisions and additions to date.
Do. do. (Railway)	1	96	Prepared for use of Railway Department.
Do. do.	1	80	Additions to railways to August 1889.
Do. do.	1	256	Ditto ditto January 1890.
Do. (Lithographed)	6	32	3rd edition in progress.
Do. Railway (Skeleton)	4	48	Outline edition, completed and published.
Do. do. do.	2	64	
Do. do.	4	48	With hills, completed and published.
Do. do.	2	64	
Burma and adjacent countries	2	32	Outline edition, completed and published.
Do. do. do.	2	32	With hills, completed and published.
Do. do. do.	2	32	2nd edition in progress.
Afghanistan	4	24	Corrections and additions to date; published.
Provincial Maps.			
Bengal, Behar, and Orissa. (Engraved)	2	16	Additions to date.
Ditto ditto ditto	2	16	2nd edition in progress.
Mysore. (Engraved)	1	16	Boundaries inserted.
Do. (Lithographed)	1	16	Ditto.
Punjab. do.	2	16	Railways inserted to date.
Rajputana. (Engraved)	2	16	Additions to date.
Divisional Maps.			
Rajshahi	2	8	Finished.
Patna	2	8	
Dacca	2	8	
Presidency	2	8	Additions to date.
Chittagong	2	8	In progress.
Orissa and Tributary States	2	8	
District Maps.			
Bannu Beerbhoom Burdwan Dinagepur Lakhimpur Purneah Sarun Shahabad Sonthal Pergunnahs	9	4	Additions to railways, roads, canals, and changes in boundaries.
Darjeeling	1	4	Completed in outline and names; published.
Lahore	2	2	Tracing made from a bad litho. print, for photo-zincography.

DRAWING OFFICE, CALCUTTA.

SECTION I—*continued.*

Statement of work—continued.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
Standard Maps.			
ASSAM—			
Sheets Nos. 43 and 44 (Khasi and Garo Hills) . . .	2	1	Railways inserted.
BENGAL—			
District Purneah.			
Sheets Nos. 3, 4, 6, 8, 11, 14, 15 and 16	8	1	Ditto.
CENTRAL INDIA & RAJPUTANA—			
Sheets Nos. 284, 312, 338, 339, 340, 341, 362, 380, 390, 391, 392, 393 and 397 . .	13	1	Completed up to margin and published.
Sheets Nos. 254, 283, 285, 368 and 389 . . .	5	1	In progress.
Sheets Nos. 115, 140, 160, 166, 200 and 203 . . .	6	1	Railways inserted.
CENTRAL PROVINCES—			
Sheets Nos. 202, 220, 235 and 236	4	1	Ditto.
Sheets Nos. 202, and 203 .	1	2	Ditto.
BOMBAY—			
Sheets Nos. 33, 34, 46, 232, 234, 235, 236, 237, 238, 270 and 274	19	1	Ditto.
MADRAS—			
Coorg.			
Sheets Nos. 32, 33, 51 and 52	4	1	Compiling from 2-inch Settlement maps.
MYSORE—			
Sheets Nos. 1 to 3, 9 to 15, 24 to 31, 42 to 54, 68 to 81, 101 to 111, 133 to 141, 169 to 172, 202 and 203 . .	70	1	Recasted headings, references, and footnotes; inserted or corrected boundaries, roads, railways, and generally completed standard sheets for photo-zincography.
N.-W. PROVINCES—			
Sheets Nos. 79, 80, 95, 111, 126, 127 and 142 . .	7	1	Railways inserted.
LOWER BURMA—			
Sheets Nos. 225 SW/2, 225 SW/4, 226 NE/1, 226 SE/1 and 226 SE/4	5	½	Headings, marginal and footnotes typed on original sheets for photo-zincography.
UPPER BURMA (N. E. FRONTIER SERIES)—			
Sheets Nos. 14 and 15 . .	2	8	Completed and published.
Sheets Nos. 15 S.E. . .	1	4	Completed to margin.
UPPER BURMA (S. E. FRONTIER SERIES)—			
Sheet No. 1 S. W. . .	1	4	In progress with outline and printing of names.
Sheet No. 1 2nd edition . .	1	8	Incorporated the work of Chin-Lushai Expedition, 1889-90, and generally brought up to date; published.
Sheet No. 2	1	8	In progress.
Do. 22 N.E. (5th edition)	1	4	Completed to margin.
Sheets Nos. 3, 3A., and 7 .	3	8	Completed and published.
NORTH-WESTERN TRANS-FRONTIER SERIES—			
1 map	1	4	Completed to margin.
1 map	1	4	Additions to sheet from material supplied by Quarter Master General.
6 maps	6	2	Headings, marginal and footnotes inserted: generally completed for photo-zincography.

DRAWING OFFICE, CALCUTTA.

SECTION I—*continued.*

Statement of work—continued.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
Administration Report Maps.			
Assam	1	48	Completed.
Bengal	1	80	Hills brush-shaded for engraving, and railways corrected to date.
Berar	1	24	Completed.
Punjab	1	32	Corrections to Baluchistan portion; and railways, canals, &c., corrected to date.
CENTRAL PROVINCES— Bilaspur, Betul, Damoh, Hoshangabad, Nimar, Narsingpur, Raipur, and Seoni	8	8	Redrawn for engraving; finished and sent for examination.
NORTH-WESTERN PROVINCES AND OUDH— Allahabad, Aligarh, Agra, Azimgarh, Ballia, Benares, Bareilly, Bahraich, Bulandshahr, Cawnpur, Etah, Etawah, Fatehpur, Furruckhabad, Gazipur, Gonda, Gorakhpur, Jaunpur, Jhansi, Lalitpur, Mainpuri, Meerut, Moradabad, Muttra, Rae-Bareilly, and Sitapur	26	8	Redrawn for engraving: finished and sent for examination.
Garhwal	1	12	
Kumaun	1	10	
Index Maps.			
Various descriptions	10	Various	Corrected to 30th September 1890.
Miscellaneous Maps.			
Chin-Lushai Expedition, 1889-90	½		Drawn from original plane-tables; published.
Reconnaissance of road from Fort Lungleh to Fort Haka	1	2	Ditto ditto ditto.
Plan of Town and Suburbs of Rangoon	9	400 ft.	Additions and corrections.
Andaman Survey Nos. 1, 2, 9, and 10	4	2	Combined for reduction to half scale by Photo-electro type.
Country between Lahore and Gujarat	1	2	Prepared for Camp of Exercise.
Country east of Barrackpur	·1	2	Drawn.
Skeleton map of Chota Nagpur	½	8	Recompiled northern half.
Hills between Nepal and Sikkim	2	2	Prepared for Government of Bengal.
Bombay Presidency (Print)	½	32	Inserted railways with changes in boundaries.
Anglo-Siamese Boundary Commission	2	4	Inserted heading, marginal, and footnotes.
Extract from War map of Persia	1	16	Prepared for Political Agent, Bassora.
S. E. Frontier Series sheet No. 2 N. E.	1	4	Upper-half prepared for Quarter Master General.
Photozincographed sheets	252	Various	Coloured for office use, &c.
Charts.			
Triangulation Chart of Gujarat	1	2	Inserted heading, footnotes, and data to stations.
From Ibrahimabad to Kushan.	1	...	
WORK DONE FOR OTHER DEPARTMENTS.			
Bengal—Registration	1	80	Showing the registration of moveable property for the three years 1887-88-89-90.
Do. Emigration	1	80	Showing the Native districts of Colonial Emigration.

DRAWING OFFICE, CALCUTTA.

SECTION I—*continued.*

Statement of work—continued.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
WORK DONE FOR OTHER DEPARTMENTS—*continued.*			
Bengal—Income Tax	1	80	Showing proportion of persons assessed to total population, 1889-90.
Bengal—Income Tax	1	80	Showing percentage of objection to assessment for each district in 1889-90.
Do. Revenue	1	80	Showing percentage of Land Revenue, 1889-90.
Do. Education	1	80	Showing extent of College Education, 1889-90.
Do. do.	2	80	Ditto Primary ditto.
Do. do.	1	80	Ditto Female ditto.
Do. do.	1	80	Ditto Mahomedan ditto.
Do. do.	1	32	Showing Western Bengal railway projection.
N. W. Provinces—Emigration	1	80	Ditto percentage of Annual Colonial Emigration, 1889.
India do.	1	96	Showing percentage of Annual Colonial Emigration, 1889.
India	1	144	To illustrate the system of registration of Inland Trade by rail and river.

DESCRIPTION OF WORK.	Number of Sheets.
Maps examined.	
Atlas sheets	28
General maps	25
Provincial maps	18
Divisional maps	14
District maps	53
Standard maps	30
Index maps	14
Statistical maps	26
Triangulation charts	1
Miscellaneous maps	44
Maps prepared for other departments	3
Engraved proofs of General and Provincial maps, including Index charts	75
Engraved proofs of District maps	76
Engraved proofs of Atlas sheets in various stages	106
Lithographic proofs of General and Provincial Maps, including Index charts	21
Lithographic proofs of Atlas sheets and District maps transferred from copper-plates	85
Lithographic proofs of Extra-departmental and Statistical maps	2
Photographic proofs of Standard sheets, large scale plans, and various other maps	395
Colouring of maps for office use	62
Tracings of maps for various purposes	3
Proofs of Professional forms	4
Projection and examination of graticules and plotting of points	56
TOTAL	1,068

N.B.—In addition to the above, many miscellaneous jobs, such as supply of geographical data to various officials, calculation of areas, computation of graticules for the projection of the sheets of the Indian Atlas, examination of the proof sheets of Survey of India Notes and of Narrative Reports of Survey Parties as to the correct orthography of names, &c., have been performed by the Examining Section.

DRAWING OFFICE, CALCUTTA.

SECTION II.—REVENUE.

Statement showing the work performed during the year 1889-90.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
STANDARD MAPS.			
PUNJAB.			
District Hissar.			
Sheet No. 256	1	1	Publication deferred pending insertion of canals from Executive Officer.
District Rawalpindi.			
Sheets Nos. 161 N. E. 4, S. E. 1; 184 N. W. 1, 2, 3 and 4; 184 S. W. 1, 2, 3 and 4; 185 N. W. 1, 2, 3; 185 S. W. 1	13	½	Press order given.
Districts Jullunder, Ludhiana, Hoshiarpur, and Umballa.			
Sheets Nos. 270, 289, 249, 293, 294 and 315	6	1	Proofs passed: press order given.
Sheet No. 227	1	1	Completed up to margin and sent to press.
Sheets Nos. 213 and 316	2	1	Completed up to margin: under examination.
Sheets Nos. 291 and 292	2	1	Under examination.
Sheet No. 294	1	½	Being completed up to margin.
Sheet No. 268	1	1	Examined and proof passed with press order to replenish stock.
Districts Jhang and Dera Ismail Khan.			
Sheets Nos. 90, 118 and 144	3	1	Examined and sent to press; first proofs received.
District Hasara.			
Sheets Nos. 1, 2, 5, 10 and 13	5	1	Originals passed with press order to replenish stock.
District Peshawar.			
Sheet No. 9	1		Ditto.
NORTH-WESTERN PROVINCES.			
District Aligarh.			
Sheets 23, 36, 37, 52 and 53	5	1	Passed: press order given.
Sheets Nos. 23 N. E., 23 S. E.; 36 N. W., 36 N. E.; 36 S. W. and 36 S. E.; 37 N. W., 52 N. W., 52 N. E., 52 S. W. and 52 S. E.; 53 N. W., 53 N. E., 53 S. W., and 53 S. E.	13	½	Press order given.
District Gorakhpur.			
Sheets Nos. 207 and 208	2	1	Press order given.
Sheets Nos. 191 and 192	2	1	Examined and sent to press: first proof received and returned for corrections.
Sheets Nos. 189, 190, 204, 205, 206, 214, 215, 188, and 213	9	1	Examined and sent to press.
Sheet No. 203	1	1	Under examination.
District Basti.			
Sheets Nos. 163, 173, 174, 175, 176, 188, and 189	7	1	Proofs sent to District Officer for examination.
Sheets Nos. 190, 191 and 192	3	½	Being completed up to margin.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

Statement of work—continued.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch	
District Mirzapur.			
Sheet No. 169	1	1	Press order given.
Sheets Nos. 182, 184, 198 and 212	4	1	Ditto
Sheets Nos. 167 and 168	2	1	Proofs sent to District Officer for examination.
Sheet No. 197 (Chakia portion)	1	1	Drawn and incorporated with sheet No. 197, reported last year.
Sheet No. 181	1	1	Drawn and completed up to margin.
Oudh.			
Sheets Nos. 98, †31, †48, 149, †51, 152, †62, 173, 175, and 192	10	1	Passed: press order given.
Sheets Nos. 98, 99, 113, 115, 131, †45, †58, 159, †72, and †73	10	1	Proofs examined and sent to press.
BENGAL.			
District Cuttack.			
Sheets Nos. 194 and 195	2	1	Press order given.
District Mymensingh.			
Sheets Nos. 346 and 362	2	1	Press order given.
Sheets Nos. 360, 363, and 374	3	1	Proofs sent to District Officer for examination.
District Hooghly.			
Sheet No. 8	1	1	Originals corrected up to date and proofs passed with final press order to replenish stock.
Hooghly River Survey.			
Sheet No. 3	1	½	Originals corrected and sent to press for a new edition.
Sheet No. 3	1	½	Originals corrected and sent to press for a new edition.
Sheet No. 3, sections F. and J.	2	1/12	
District 24-Pergunnahs.			
Sheet No. 3	1	1	Proofs examined and passed with press order to replenish stock.
District Sylhet.			
Sheets Nos. 1 to 11 (Pergunnah maps)	11	1	Proofs examined and passed with press order to replenish stock.
District Patna.			
Sheet No. 1 (Pergunnah map)	1	1	Proofs examined and passed with press order to replenish stock.
District Sarun.			
Sheets Nos. 4, 4, 9, 10, 11, 12, 15, 16, 19, and 23 (Pergunnah maps)	10	1	Maps rendered suitable for photo-zincography and sent to press.
District Monghyr.			
Sheets Nos. 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, and 13 (Pergunnah maps)	11	1	Maps rendered suitable for photo-zincography and sent to press.
ASSAM.			
District Lakhimpur.			
Sheets Nos. 4 and 5	2	1	Passed: press order given.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

Statement of work—continued.

TITLE.	Number of Sheets.	Scale.	REMARKS.
Districts Darrang and Kamrup.		Miles per inch.	
Sheets Nos. 25 and 39 . .	2	1	Typed, examined, proofs passed with press order.
Sheets Nos. 26 and 27 . .	2	½	Typed and examined with 16-inch plans.
Sheets Nos. 28, 38, 40, 41, 49 and 51	6	½	Typed: held in abeyance.
Sheet No. 50	1	½	Typing in hand.
CENTRAL PROVINCES.			
District Sambalpur.			
Sheets Nos. 236, 237, 238, 239, 251, 252, 253, 254, 262, 263, 264 and 265	12	1	Examined, corrected, and proofs sent to District Officer for reference.
BOMBAY.			
Sheets Nos. 205, 305, 306 and 307	4	1	Press order given.
Sheets Nos. 332 and 333 . .	2	1	Examined and sent to press.
Sheets Nos. 145 and 146 . .	2	1	Examined and proofs sent to District Officer for reference.
Sheet No. 277	1	½	Under examination.
Sheet No. 233	1	1	Corrected up to date and sent to District Officer for reference and examination.
Sheets Nos. 160 N. W. 1 and 3, N. E. 3, S. W. 1, 2, 3 and 4, and S. E. 1, 3 and 4.	10	¼	Passed with press order.
BURMA (LOWER).			
Sheets Nos. 142, 187, 234, 281 and 329	5	1	Press order given.
Sheets Nos. 229, 230, 235, 236, 275, 278, 277, 322 and 328 .	8	1	Originals drawn and sent to press.
Sheets Nos. 282, 283, 323, 324 and 328	5	1	Originals drawn; sent to press and proofs examined and returned to press.
Sheets Nos. 325 and 327 . .	2	1	Drawing finished: under examination.
District Akyab.			
Sheets Nos. 45 and 47 . .	2	1	Press order given.
Sheets Nos. 24, 26, 27, 43, 44 and 46	6	1	Examined; proofs received and returned to press for corrections.
Sheets Nos. 8, 9 and 25 . .	...	...	Examined and sent to press; proofs received and sent to Local Officers for examination.
PLANS OF CITIES AND CANTONMENTS.			
Benares City including Sikraul and Pandipur Cantonments .	4	⅛ / ⅙	Passed with final press order.
City of Calcutta	2	⅙	Proofs corrected, final press order given.
Do do.	13	1 / 25·4	Plotting examined, held in abeyance.
MISCELLANEOUS.			
Maps of Hutted Camps, Kalabagh, Baragali, Ghora, Dhaka, Khyra Gali, Chanda Gali, and Thobba	6	1/12	Proofs examined and press order given.
Usar Map of Oudh . . .	6	8	Drawn and sent to press. Proofs forwarded to the Revenue and Agricultural Department for examination.
Reh Map of Punjab . .	8		Drawn from data supplied by the Punjab Government and sent to press.
Sketch Map of country in the neighbourhood of Barrackpur .	1	⅛	Drawn and press order given.
INDEX MAPS.			
For Annual Administration Report	12	...	Drawn and sent to press.
Do. do. .	13	...	Corrected, brought up to date, and sent to press.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

Statement of work—continued.

TITLE.	Number of Sheets.	Scale.	REMARKS.
PROOF EXAMINED.		Miles per inch.	
Photozincographed Maps . .	313		
Lithographed Maps . .	63		
TRACINGS PREPARED.			
Tracings of Sheets . . .	20	...	
Do. of Village Plans . .	49	...	
MAPS COLOURED.			
Maps on various scales . .	103	...	For Surveyor-General's Office.
Do. do. . .	103	...	For Deputy Surveyor-General's Office.
Do. do. . .	328	...	For India Office.

DESCRIPTION OF WORK.	REMARKS.
Computations examined.	
District Kamrup, seasons 1883-86.	
District Darrang, „ 1885-87.	
Traverse Data, &c., supplied.	
District Moradabad along Rampur State . . .	To Colonel J. E. Sandeman.
Nepal Boundary along Rohilkhand	Ditto.
Hanthawaddy along China Bakir river and the Gulf of Mattaban	To F. W. Kelly, Esq.
Goalpara along Bhutan	To Conservator of Forests.
Main Circuit No. 10, Hanthawaddy . . .	To E. J. Jackson, Esq.
District Bassein (portion of)	Ditto.
Sind and Punjab Boundary	To Surveyor.
Hanthawaddy along unsurveyed portion . . .	To E. J. Jackson, Esq.
Mezali, Linga, and other Circles, District Bassein .	Ditto.
Main Circuit No. 26, Ganges Doara Survey . .	To Deputy Collector, Kushtea.
Narsingpur Forest Boundary	To G. H. Cooke, Esq.
Village traverses supplied, 131 pages . . .	To public officers.
Alphabetical statement of villages in Pargana Kotwalee.	To Circle Officer, S. W. Estate.
Miscellaneous.	
Calculated rectangular co-ordinates of G. T. S. in and around Lucknow, of pillars and other points along Goalpara and Bhutan boundary, of Kamptee cantonments, of district Lakhimpur; also latitudes and longitudes of pillars along Sind and Punjab boundary, and of points in district Saugor for projection. Plotted 13 sheets of the western bank of Rangoon river for Executive Engineer, Defence Works, on 16″ scale; one village of Khorda estate on 32″ scale for settlement officers; 4 groups of congregated villages for the Collector of Pubna.	
Calculated areas by *parganas* of North-Western Provinces Survey, 14 sheets; Punjab Survey 2 sheets; Assam Survey 1 sheet; also of district Benares by *parganas* and *tahsils*; and of the Native States in district Kangra, computed in duplicate secondary triangles of the Chin-Lushai expedition.	

DRAWING OFFICE, CALCUTTA.

SECTION III.—CADASTRAL.

State of Publication of Cadastral Maps on the 30th September 1890.

DISTRICTS.	NUMBER OF SHEETS.							REMARKS.
	MAPS PREPARED.			PUBLISHED.				
	Up to 30th September 1889.	Added during past 12 months.	Total up to 30th September 1890.	Up to 30th September 1889.	By Surveyor-General's Office during past 12 months.	Total to 30th September 1890.	Remaining to be published.	
North-Western Provinces.								
Agra	2,942	...	2,942	2,942	...	2,942	...	
Azamgarh	930	...	930	930	...	930	...	
Ballia	1,601(a)	...	1,601(b)	1,396	205(c)	1,601	...	
Banda	3,317	...	3,317	3,317	...	3,317	...	
Basti	5,557	...	5,557(b)	3,360	1,493	4,853	704	
Benares	2,052	...	2,052(b)	2,052	...	2,052	...	
Bijnour	31	...	31	31	...	31	...	
Dehra Dun	701	...	701	701	...	701	...	
Fyzabad	14	...	14	14	...	14	...	
Ghazipur	4,021(a)	...	4,021(b)	3,391	630(c)	4,021	...	
Gorakhpur	8,637(a)	...	8,637(b)	4,285	881	5,166	3,471	
Hamirpur	2,926	...	2,926	2,926	...	2,926	...	
Jaunpur	3,583(a)	...	3,583	3,434	149(c)	3,583	...	
Moradabad and Tarai	4,023	...	4,023	4,023	...	4,023	...	
Muttra	1,658	...	1,658	1,658	...	1,658	...	
Mirzapur	3,710(a)	...	3,710(b)	3,639	71(c)	3,710	...	
Tarai	409	...	409	409	...	409	...	
TOTAL	46,112	...	46,112	38,508	3,429	41,937	4,175	
Burma.								
Akyab	2,741	...	2,741	2,741	...	2,741	...	
Bassein	3,437	...	3,437	3,425	12	3,437	...	
Hanthawaddy and Pegu	4,601	...	4,601	4,601	...	4,601	...	
Henzada	1,391	...	1,391	1,391	...	1,391	...	
Prome	847	...	847	847	...	847	...	
Tharrawaddy	1,363	...	1,363	1,363	...	1,363	...	
Thongwa	979	1,325	2,304	63	1,018	1,081	1,223	
TOTAL	15,359	1,325	16,684	14,431	1,030	15,461	1,223	
Bengal.								
Patna and Gya	3,054	...	3,054	3,054	...	3,054	...	
Pooree (Khorda Estate)	4,565	...	4,565	4,565	...	4,565	...	
Shahabad	4,924	...	4,924	4,924	...	4,924	...	
Mozufferpur	1	...	1	1	...	1	...	
TOTAL	12,544	...	12,544	12,544	...	12,544	...	
Assam.								
Darrang	718(a)	...	718	703	1	704	14	
Kamrup	1,675	...	1,675	1,675	...	1,675	...	
Nowgong	449	304	753	435	99	534	219	
Sylhet	61	...	61	16	...	16	45	
TOTAL	2,903	304	3,207	2,829	100	2,929	278	
Central Provinces.								
Raipur	43	...	43	43	...	43	...	
TOTAL	43	...	43	43	...	43	...	
GRAND TOTAL	76,961	1,629	78,590	68,355	4,559	72,914	5,676	

(a) Figures of previous return have been changed to agree with final results.

(b) These figures are liable to alteration until publication has been completed.

(c) These maps have been reprinted.

Abstract of work performed during 1889-90.

PROVINCES.	NUMBER OF SHEETS.				REMARKS.
	Examined and rendered suitable for photo-zincography.	Traced and examined for zincography.	Proof sheets examined previous to press order.	Coloured and subsequently examined.	
North-West Provinces	2,508	754	3,387	3,429	Scale, 16 inches = 1 mile.
Burma	470	548	1,019	1,030	Ditto ditto.
Bengal	...	...	...	...	...
Assam	119	8	110	...	Ditto ditto.
TOTAL	3,097	1,310	4,516	4,459	

Photo-etching. Survey of India Offices, Calcutta, August 1890.

STREET SCENE IN HYDERABAD (DECCAN).

From a negative by Surgeon A. G. F. Newland.

ENGRAVING OFFICE, CALCUTTA.

Statement showing the work performed during the year 1889-90.

Title of Map.	Number of sheets.	Outline, square inches.	Number of letters cut.	Hills, square inches.	Remarks.
Engraving.					
Indian Atlas.					
Scale, 1 inch=4 miles.					
Quarter sheets (new), completed	2	1	709	22	
Ditto in progress	39	1,499	89,874	540	
Additions and corrections to published quarter sheets	27	58	6,980	17	
Additions and corrections to published full sheets	9	139	5,525	274	
New plates projected, &c.	10	....	536	...	
General Maps	27	518	30,749	63	
Provincial Maps—					
On scale 1 inch=16 miles	13	277	42,070	11	
On various scales for Administration Reports	5	64	3,276	...	
District Maps for Administration Reports	49	1,324	48,341	239	
Index Maps	9	398	36,927	...	
Charts	1	...	32	...	
Miscellaneous plates	41	...	19,972	...	
Totals	232	4,272	2,84,991	1,166	

Copper-plate Printing.

Impressions taken	20,588
Proofs pulled	627
Transfers pulled	382
Total	21,597

Steel Facing.

Double elephant plates steel faced	18
Double elephant plates steel removed	14
Quarter sheets steel faced	52
Do. do. steel removed	24
Miscellaneous plates steel faced	84
Miscellaneous plates steel removed	29
Total	221

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE, CALCUTTA.

Extract from the Narrative Report of Colonel J. Waterhouse, S.C., *Assistant Surveyor-General—Season 1889-90.*

In the last report it was anticipated that the Photographic and Lithographic Offices would be formally amalgamated during the year, but owing to various considerations this important step has had to be postponed. In the meantime, however, the working of the two offices is being assimilated and gradually combined, while experience is being gained which will greatly facilitate the final amalgamation. The arrangements for this are well advanced and only require putting into definite shape, which will be done almost immediately.

Out-turn.—The out turn shows a very considerable increase in nearly all items, and even in cases where a decrease is shown the actual work involved has been more. The whole establishment has been fully occupied during the year. Without the aid of the new steam machinery it would have been quite impossible to have dealt with the large increase of work, especially in colour printing.

Original Subjects.—The total number of original subjects received for reproduction during the year has been 7,021 (including 4,548 cadastral maps), of which 731 have been

dealt with by lithography and 1,742 by various processes of photography and by zincography The increase over last year on the whole is about 1,481.

The number of departmental maps, plans and forms lithographed was 143, or 17 less than last year, 588 original subjects were received from other departments, or 55 less than last year.

On the photographic side the total number of subjects received for reproduction was 6,290, of which 1,068 were departmental, 4,548 cadastral and 674 extra-departmental. Last year the total number of subjects received was 4,737, of which 799 were departmental, 3,587 cadastral and 351 extra-departmental. There has consequently been a large increase in this work all through.

LITHOGRAPHIC DRAWING SECTION.—The total number of new drawings, or additions made to maps, &c., on stone, taken up and completed during the year was 645, of these only 57 were departmental, the remaining 593 being for other departments. Last year, out of a total number of 712 subjects, 643 were extra-departmental and 69 departmental.

The section has remained under charge of Mr. H. L. Lepage, Head Assistant, and there is nothing new to record.

PHOTOGRAPHIC NEGATIVE SECTION.—The total number of negatives taken during the year was 5,600, including 56 reversed negatives and transparencies for use in the heliogravure process; of these 1,308 were of departmental and 1,051 of extra-departmental maps, plans and drawings, as against 1,264 and 713, respectively, last year, besides 3,241 cadastral maps against 2,819 of last year.

The section has been in charge of Mr. H. Haward and the processes have all remained the same. The arrangements of the new building have been found to work well and the dark rooms have been very effectively ventilated in a simple and inexpensive manner by substituting for the double doors at each end, a winding open passage so constructed as to let in air and allow free passage to the assistants in and out without admitting light. During the hot weather it was found that there was a strong current of air constantly passing through the dark rooms, and though they were not actually cooled, fresh air was constantly admitted and all fumes of chemicals, &c., quickly and effectively removed. A large Boyles' exhaust ventilator, which came out from Europe with the glass-house, was fixed on the roof, so as to draw the air from the two large dark rooms of this section, and this adds to the free ventilation already described, by drawing off the upper strata of heated air.

PHOTO-TRANSFER PRINTING SECTION.—The number of photo-transfer prints prepared was 5,148, of which 945 were departmental and 973 extra-departmental and 3,230 cadastal maps, and there is an increase of 635 over last year. Mr. J. Harrold has remained in charge of the section, and there have been no changes in the processes. The new arrangements have all worked satisfactorily.

LITHOGRAPHIC AND ZINCOGRAPHIC PRINTING SECTION.—Although the lithographic and zincographic printing is done by two separate establishments, the two classes of work are being gradually amalgamated and may be treated together. Consequent on the introduction of the new steam machinery, many subjects which would formerly have been printed from stone are printed from zinc, and as zinc plates are so much more easily handled than stones, their use is likely to extend. In the Lithographic Printing Section the number of subjects printed from stone was 633, the number of pulls being 2,80,564 and of copies 2,56,909, of these 122 subjects with 107,699 pulls and 80,297 copies were departmental and 511 subjects, with 1,72,865 pulls and 1,76,612 copies were for other departments. As compared with last year there is a decrease of 19 in the number of subjects and of 62,256 in the number of pulls to be accounted for by the increasing use of zinc as before explained. In the Zinc Printing section (normal) the number of plates printed was 1,041 (360 departmental and 681 extra-departmental), the number of pulls being 209,634 (54,680 departmental and 1,54 954 extra departmental) and of complete copies 306.440 (55.353 departmental and 2,51,087 extra-departmental). As compared with last year this shows an increase of 398 in the number of plates printed, of 86,372 in the number of pulls, and of 125,792 in the number of copies. Both the departmental and extra-departmental work in this section have largely increased. In the Zinc Printing Section (cadastral) 4,499 plates of cadastral maps were printed off, the number of pulls being 1,08,799 and of copies of complete villages 99,354, as against 3,642 plates, 1,03,882 pulls and 96,290 complete copies printed off last year.

The feature of the year has been the introduction of steam machinery into the printing room, and I am glad to be able to report that it has been quite successful. Owing to various causes of delay, the shafting was not set up till March, and though the small machines were started in May the large zincographic machine did not commence running until July. Since that time, although this machine has seldom been worked to its full power, it has been of the greatest service and it has more than once been found worth while in urgent cases to print off even a very small number of copies in it. By the use of zinc plates instead of stone, this can easily be done with very little loss of time in changing plates; five or six standard sheets can easily be printed off in a day, while by hand they would take the zinc printing establishment four to six days. There is thus a very large economy of time and labour. Although it was important to be able to utilise the large stock of thick zinc plates already available in the office, the use of thin zinc sheet has been found to be a great improvement, though its use has been confined to the smaller sizes. A bed has, therefore, been indented for from England to take thin zinc plates of the full double elephant size. The thin plates are much cheaper than the thick ones, and can be more

easily stored, while if required to be kept, there is not the same loss of capital locked up as there is with the ordinary zinc plates and still more with stones.

The small lithographic machine, which was formerly worked by hand, has made a much larger and better out-turn by the substitution of steam for hand-power, and with it also the tendency is to print as much as possible on thin zinc plates. That zinc is capable of replacing stone is proved by the fact that from a single plate of a weather chart no less than 22,800 copies were printed and the plate was then quite in good order.

Without the steam machinery it would have been quite impossible for the office to have met the increased demands that have been made upon it during the year. Ample employment has been found for the hand-presses since the machinery started and at present there seems to be quite sufficient work for both machines and hand-presses, and very little reduction can be made in the printing establishment.

The arrangements of the printing room have all worked well and the convenience of having all the presses and the draftsmen together has been fully proved. In the hot weather the galleries were found to be rather too hot for zinc printing in the afternoons and it was necessary to revert to the old system of opening the office in the early morning from April to June.

The materials for preparing Patent Litho Plates were received from England, but since Mr. B. Mackenzie's return from furlough the pressure of current work has been so heavy that there has been no time to go into the process of preparing plates which he learnt in England, and it is found that in the machine the ordinary thin zinc plates give almost, if not quite, as good results as the prepared ones for all practical purposes. During his furlough Mr. B. Mackenzie visited the Ordnance Survey Office at Southampton, and other large printing establishments, and gained a good deal of information which will be useful.

TYPE PRINTING SECTION.—The work in this section also shows a very large increase in the number of items received and in the number of copies printed, though the number of pulls is less. The number of items received was 9,918 against 6,646 of the previous year, or close upon half as much again. The number of pulls was 1,061,577 and of copies 573,885 against 1,177,175 and 534,257 of the previous year. The falling off in the number of pulls may be accounted for by the fact that smaller numbers of copies have been required, but the actual work of composing and printing has been much greater. The new Caxton Platen Machine has worked well. It gives a good impression and has proved very useful for printing small forms. The section has continued under charge of Mr DePyvah.

SILVER PRINTING SECTION.—The amount of silver printing has been very small, only 179 prints having been produced during the year. On the other hand, the use of blue cyanotype prints has been very largely extended; these prints being now used as 'proofs' in cases where it is probable that heavy corrections will be made and the final publication of a map delayed. Formerly such maps were transferred to zinc and then laid aside perhaps for a year, and in some cases more, thus uselessly locking up a large number of zinc plates. The total number of blue prints produced during the year has been 2,823 against 1,096 of last year, showing an increase of 1,727. The blue-print proofs are made on the ordinary lithographic paper. At first some trouble was found in consequence of the prints taking an unpleasant yellowish brown colour on drying, but this is easily removed by soaking the prints for a short time in a 2 per cent. solution of oxalic acid. For convenience the work of the section has lately been attached to the Transfer Printing Section, supervised by Mr. Harrold, and carried on by Mr. P. Michael, one of the apprentices.

HELIOGRAVURE AND COLLOTYPE SECTIONS.—These sections have remained under charge of Mr. A. W. Turner. As the heliogravure process is so successfully worked and has superior advantages in many ways over collotype, the latter process has almost gone out of use. During the year 12 plates have been prepared and 3,432 copies printed for the Geological Survey of India and the Indian Museum. The out-turn of heliogravure shows a good increase, 56 plates have been prepared and 30,589 copies printed off, showing an increase of 6 in the number of plates and of 10,282 in the number of copies printed as compared with last year. The printing of all subjects other than departmental maps has been entirely carried out by the presses attached to the section in this office.

PHOTO-ETCHING PROCESS.—Most of the heliogravure work produced during the year has been done by this method without any material alteration in the way of working described in former reports. The experience gained by continuous use of the process at all seasons of the year gives greater certainty in obtaining the desired results with varied subjects, as also a greater power of controlling pictorial effect by judicious manipulation of the transparency in regard to exposure and intensification and by the use of stronger or weaker etching solutions. The work has been of a very miscellaneous character and the demands have been fairly steady, now the advantages of the process are becoming known.

ELECTROTYPING.—The reproduction of hand engraved plates by electrotyping, either as matrices or duplicates, has been carried on steadily during the year and 17 plates have been turned out in this way, or 5 more than last year. The new steam milling machine has proved very useful for trimming the edges of these plates before separating them after coming out of the battery and is a very great improvement on the old method of filing them.

As it appeared that the large apparatus in use in the Engraving Office for steelfacing copper plates was not quite suitable for steelfacing the small plates ordinarily produced in this section, a new apparatus of a smaller size worked by two cells of the Silvertown Company's battery was made up and gives excellent results.

PHOTO-TYPOGRAPHIC BLOCKS.—Further experiments have been tried with the object of obtaining good printing blocks of half-tone subjects suitable for printing with type. Some promising results were obtained, but although it is comparatively easy to obtain good blocks, it is very difficult to get the best results from them for want of printers properly trained to delicate work of this kind.

Very fair results may be obtained by first exposing a piece of sensitised autotype tissue under a fine wire gauze, or a plate with ruled lines or dots on it, for about a minute in the sun. It is then removed from the frame and again exposed under an ordinary half-tone negative and developed on glass to form a transparency, covered with an image of the wire gauze or ruled lines under which it was first exposed. From this transparency a second negative is obtained in the camera by the ordinary wet collodion process used for copying. This negative can then be printed from direct on zinc by the asphaltum process or on paper for transfer by the ordinary methods of photozincography. The image is then etched with nitric acid at 3 per cent. for about 30 minutes and may then be washed off with benzole rolled up with a fine rubber roller and strong ink and rebitten to the necessary depth. Another method which Mr. Turner found to answer well was to take a print in autotype tissue of the grained negative and develope it on a copper plate. When dry the image is etched with one strong solution of perchloride of iron, but repeated re-biting is required to obtain sufficient depth. The advantage of the method is that the fine lines and dots are not so easily bitten away as is the case with an image produced directly on the plate in asphalt or by transfer.

I obtained privately from Europe some plates of ruled lines with the object of working out this process, but have not had time to devote to it. It seems likely that the development of these processes will result in producing half-tone images on zinc or stone which may be printed rapidly and cheaply in the zincographic machine. Such prints would be very useful for many ordinary purposes of illustrating reports, &c., and could be supplied in large numbers much more quickly and cheaply than heliogravure prints.

EXPERIMENTAL AND PERSONAL WORK.—The new laboratory and dark room attached to the Superintendent's office afford much greater facilities for experimental work than formerly existed in the old office, and consequently a great variety of experimental work in printing processes and new methods of developing dry plates have been undertaken during the year.

Experiments with celluloid have shown that it can advantageously be used as a material for drawing upon either with pen and ink, lead pencil, or black chalk with a view to direct reproduction by heliogravure. Some large sheets of the material were obtained through the India Store Department for trial on a practical scale, but the quality was inferior to the small samples first tried and it seems impossible to secure flatness in large sheets. It was also found that transfers could be made to celluloid in the same way as to stone or zinc and printed from, but it was difficult to keep the ground clean, the ordinary gum solutions, even with the addition of acetic acid which is a solvent of celluloid, not having the same effect in keeping the ground clean and quite repellent of ink as with stone or zinc. The advantages of substituting a light, unbreakable material of a good colour for drawing and printing upon for stone or zinc are obvious, and it is to be hoped that some means of getting over the difficulty of keeping the surface clean may yet be found.

Hydroquinone and eikonogen have been tried with success as developing agents for dry plates. It was found also that guaiacol or meta-pyrocatechin, an oily liquid produced from gum guaiacum, &c., possessed good developing powers, though not nearly so strong as pyrocatechin and the ordinary dry-plate developers. The smell of guaiacol is unpleasant, and it is not likely to come into use, but the discovery is of interest as it appears to be the first instance of a liquid developing agent being used.

In the course of some experiments with eikonogen it was found that some of the thio-carbamides or sulpho-ureas, when added in very small quantities to this developer possessed the remarkable property of producing a positive image instead of a negative one, even with very short exposures. A very large number of experiments were tried privately with phenyl-thio-carbamide, allyl-thio-carbamide or thio-sinamine, prepared by acting on the essential oil of mustard with ammonia, and with thio-carbamide or sulpho-urea, prepared by decomposing sulpho-cyanide of ammonium by heat. All these three sulpho-ureas were found to cause reversal of the image, but ordinary urea did not. The difficulty in working the process successfully is the adjustment of the exposure to suit all parts of the picture, and as over-exposure prevents reversal, the high lights are apt to be non-reversed, while the shadows may be too deep. In copying, and especially with line subjects, reversal can more easily be obtained than with landscape or outdoor work with strong lights and deep shadows, but it is difficult to obtain the same clearness in the lights as with wet collodion or an ordinary dry plate transparency, obtained either by contact or in the camera; though some results lately obtained with a compound of thio-carbamide and ammonium bromide are almost perfect.

Phenyl-thio-carbamide and thio-sinamine (allyl-thio-carbamide) have both given good

results for line and half-tone work; thio-carbamide by itself has not proved so effective, it being a powerful accelerator of development, very short exposures are necessary. It has, however, been found that a compound of thio-carbamide with ammonium bromide, which was discovered some two years ago by Professor J. E. Reynolds and described by him in the Journal of the Chemical Society of London for 1888, has given very good results indeed. It is prepared by adding together boiling alcoholic solutions of 1 part of ammonium bromide and of 3 parts of thio-carbamide and continuing the boiling for a time. On cooling, the mixture sets into a crystalline mass. The addition of a small quantity of the saturated alcoholic solution of this salt to the ordinary eikonogen developer in the proportion of about 5 drops to the ounce, causes very complete reversal of the image with exceedingly short exposures.

Wratten's 'ordinary' plates have been found to answer best, and a suitable eikonogen developer is formed by mixing 1 part each of eikonogen, sodium sulphite and lithium carbonate with 100 parts of water, but the proportions may be varied and other alkaline carbonates used.

Of phenyl-thio-carbamide about 1 part of the saturated solution at 1 to 1,000 may be added to 7 parts of the developer, and it is also an advantage to add about 1 per cent. of a solution of bromide of ammonium at 10 per cent., or about 5 drops per fluid ounce. The further addition of a very little solution of ammonia has also been found useful in completing the reversals.

Of thio-sinamine about 1 per cent. of the watery saturated solution added to the developer as above is sufficient, and the same addition of alkaline bromide and of ammonia may be made.

Of the compound salt of tetra-thio-carbamide ammonium bromide about 1 per cent. may be added to the developer, and there seems to be no necessity for any further addition of alkaline bromide or ammonia.

It has been found that the completeness of the reversal and the density and clearness of the image, especially in copying, may be increased by a preliminary treatment of the plate before development with an oxidising agent such as dilute nitric acid at from 2·5 to 5 per cent. or a 3 per cent. solution of bichromate of potash. These solutions are applied for a few seconds to the plate and then well washed off. The nitric acid treatment has been found to work best with phenyl-thio-carbamide and the compound tetra-thio-carbamide salt, the bichromate treatment answering best with the thio-sinamine.

It also adds in some cases to the clearness of the image to treat the plate after development and before fixing with a solution of cupric bromide at 2 to 3 per cent. This clearing operation may also be performed with advantage after fixing.

The process still requires a great deal of working out to ascertain the conditions of success and to obtain more perfect results. The first experiments with it were made in the months of July to October, under many disadvantages, and I have not been able to devote much time to it since. It appears, however, to work much better in cool weather, and it is hoped that further experiment during the present cold season may result in finding a way of working this very interesting discovery in a really practical manner.* From the experience I have gained and from the results obtained by others who have tried the process in Europe and America, it seems likely to succeed, and if it does it will form a ready means of obtaining the reversed positives required for the heliogravure process directly in the camera instead of having to produce them by the carbon process which is always more or less uncertain, especially in hot weather, and it would have many other important applications, especially in astronomical photography.

NEW BUILDINGS AND MACHINERY.—Beyond a few petty works for ventilation and the erection of a packing and drying shed in the compound, no new work has been done during the year. The buildings have proved exceedingly commodious and convenient and are in every way an enormous improvement over the old offices. The concentration of the staff within one building has been found to very greatly facilitate the work of supervision and to increase the efficiency of the establishment.

The boiler and all the new machinery, with the exception of the engine and steam fittings, were set up in October and November 1890, but the setting up of the engine, shafting and steam fittings had to be delayed till the arrival from Europe in March of the A standards and brackets for the shafting, and the working by steam could not begin until the 23rd May. Owing to the necessity for further strengthening the shafting the large quad-crown lithographic machine was not started till the 18th July, but since that date the whole of the machinery has been more or less constantly at work and there have been no hitches or failures. This result is very satisfactory, especially considering that the engine and its fittings as well as much of the machinery, is quite novel in this country, and that it has been worked by a native engine-driver and the ordinary staff of the office.

* Further experiments made while this report has been passing through the press seem to indicate that these reversals are due to electro-chemical action set up by the silver sulphide which is formed in the unexposed parts of the plate by the mixture of thio-carbamides with alkali. This is accompanied by a reversal of current, and whereas in the ordinary alkaline developing process for dry plates the exposed parts of the sensitive plate form the negative pole and produce a negative image, in developing with alkaline thio-carbamides, the exposed parts form the positive pole and produce a positive image. If this can be fully proved, it may throw a good deal of light on the theory of photography.

Specification of Plate or Print.	Sheets or subjects.	Negatives and transparencies.	Photo-zincographic and Lithographic Printing:							
			Photo-transfer prints.	Zinc plates transferred.	Zinc plates printed.	Stones.	Pulls.	Number of Copies.		
								Coloured.	Uncoloured.	Total.
Departmental Maps and Plans.										
General Maps	78	44	94	42	41	26	41,096	520	8,851	9,381
Provincial Maps	15	25	19	5	13	6	1,590	...	1,640	1,640
Divisional Maps	3	3	3	1	4	...	650	...	650	650
District Maps	47	52	55	24	47	12	3,605	...	4,465	4,465
Plans of cities and cantonments	61	119	112	32	20	7	1,700	50	1,500	1,550
Standard Maps	449	688	546	250	177	15	26,898	...	26,508	26,508
Index Maps	69	49	30	30	32	30	46,315	22,860	10,025	32,885
Technical Charts	5	6	6	3	6	...	225	...	225	225
Miscellaneous Maps and Plans	469	319	75	29	48	46	18,918	2,450	16,796	19,246
Transfers and Proofs	...	...	...	...	...	...	2,282	...	...	...
Departmental Forms	15	...	...	...	...	24	50,100	...	39,100	39,100
Type Printings	...	...	...	...	...	...	...	...	...	...
TOTAL	1,211	1,308	945	316	360	165	162,379	25,890	109,760	135,650
Cadastral Maps.										
North-Western Provinces—										
Photo-zincographs	2,632	2,632	2,612	2,586	2,586	...	45,001	...	45,001	45,001
Zincographs	777	...	...	777	777	...	13,819	...	13,819	13,819
TOTAL	3,409	2,632	2,612	3,363	3,363	...	58,820	...	58,820	58,820
Burma—										
Photo-zincographs	496	496	500	510	510	...	17,274	...	17,274	17,274
Zincographs	522	...	...	522	522	...	17,748	...	17,748	17,748
TOTAL	1,018	496	500	1,032	1,032	...	35,022	...	35,022	35,022
Assam—										
Photo-zincographs	113	713	118	96	96	...	5,088	...	5,088	5,088
Zincographs	8	...	...	8	8	...	424	...	424	424
TOTAL	121	713	118	104	104	...	5,512	...	5,512	5,512
Transfers and Proofs	...	...	...	...	...	...	91445	...	...	...
GRAND TOTAL	4,548	3,741	3,230	4,499	4,499	...	108,799	...	99,354	99,354

LITHOGRAPHIC OFFICE.

done during the year 1889-90.

Type Printing.			Silver and other Printing.			Heliogravure and Electrotyping.				Photo-collotype.		Value.	Remarks.
Pages or items.	Puffs.	Copies.	Silver prints.	Blue prints.	Miscellaneous prints.	Heliogravure plates.	Heliogravure prints.	Photo. blocks.	Electrotypes.	Photo-collotype plates.	Photo-collotype prints.	£ s. d.	
...	...	...	...	...	...	...	...	...	...	...	...	5,982 9 3	Four subjects not yet printed.
...	...	...	...	6	...	...	...	...	...	...	...	1,199 13 0	One subject not yet printed.
...	...	...	...	24	...	...	...	...	...	...	...	239 2 6	.....
...	...	...	2	42	...	...	...	...	...	...	...	2,449 8 6	Eleven subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	...	...	3,474 11 0	Two subjects not yet printed.
...	...	...	...	1,324	...	...	...	...	...	...	...	21,133 15 3	Two subjects not yet printed.
...	...	...	...	191	...	...	...	...	...	...	...	2,394 2 0	.....
...	...	...	...	...	...	...	...	...	...	...	...	122 13 9	.....
...	...	...	52	1,059	...	19	2,417	6	17	...	60	8,308 6 0	One subject not yet printed.
...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	5,787 6 0	
9,918	1,064,577	573,885	...	...	...	...	...	...	...	...	...	17,516 4 0	
9,918	1,064,577	573,885	54	2,645	...	19	2,417	6	17	...	60	69,618 13 3	
...	...	...	...	...	...	...	...	...	...	...	...	39,632 13 9	
...	...	...	...	...	...	...	...	...	...	...	...	6,165 14 0	
...	...	...	...	...	...	...	...	...	...	...	...	45,798 11 9	
...	...	...	...	...	...	...	...	...	...	...	...	8,668 6 0	
...	...	...	...	...	...	...	...	...	...	...	...	4,701 12 0	
...	...	...	...	...	...	...	...	...	...	...	...	12,830 2 0	
...	...	...	...	...	...	...	...	...	...	...	...	2,046 9 6	
...	...	...	...	...	...	...	...	...	...	...	...	102 0 0	
...	...	...	...	...	...	...	...	...	...	...	...	2,148 9 6	
...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	60,817 7 3	

Statement of work done for other

Departments, &c.	Sheets or subjects.	Negatives and transparencies.	Photo-zincographic and Lithographic Printing.					Number of Copies.		
			Photo-transfer prints.	Zinc plates transferred.	Zinc plates printed.	Stones.	Pulls.	Coloured.	Uncoloured.	Total.
Adjutant General in India	84	5	5	16	17	26	8,515	100	14,605	14,705
Agent and Chief Engineer, Bengal and N. W. Railway	...	...	...	...	1	...	100	...	100	100
Agent and Chief Engineer, Rohilkund and Kumaun Railway	7	7	7	4	...	...	...	...	...	...
Asiatic Society, Bengal	13	8	2	1	...	2	1,335	...	1,335	1,335
Board of Revenue, Bengal	21	2	2	24	44	19	24,993	14,993	800	45,793
Boundary Settlement Officer, Mewar	1	...	...	...	...	1	200	...	200	200
Calcutta Municipality	10	3	...	...	...	4	1,600	...	2,800	2,800
Chief Commissioner, Assam	2	...	...	...	...	3	8,900	450	8,000	8,450
,, ,, Burma	8	10	10	3	4	4	1,170	385	400	785
,, ,, Central Provinces	*10	15	...	1	5	1	1,385	...	2,410	2,410
,, ,, Coorg	...	...	...	...	1	...	180	...	180	180
,, Engineer, Bengal, P. W. D.	28	118	112	59	89	...	18,800	...	27,145	27,145
,, ,, Bikaneer Desert Railway Survey	4	...	...	...	...	3	400	...	450	450
Collector of Customs, Calcutta	16	...	...	...	...	4	480	...	1,920	1,920
Commandant, Central India Horse	2	6	6	...	...	1	20	...	20	20
Commissioner of Chota Nagpur	...	...	...	6	6	...	4,272	3,560	...	3,560
Commissioner of Excise, Bengal	4	...	...	...	...	5	1,420	1,035	40	1,075
,, ,, Punjab	8	...	...	...	...	8	1,720	1,720	...	1,720
,, of Settlement and Agriculture, Central Provinces	3	7	7	2	...	1	2,000	...	2,000	2,000
Commissioner of Police, Calcutta	1	...	...	...	...	2	2,684	1,042	...	1,042
,, of Chittagong Division	...	...	...	1	...	...	...	...	...	...
Commissary General-in-Chief	9	...	...	...	...	8	8,777	...	11,277	11,277
Consulting Engineer to Government of India for Railways	5	...	...	...	...	5	603	...	603	603
Deputy Commissioner, Mandalay	153	224	224	152	325	1	3,926	...	4,526	4,526
,, ,, Darjeeling	2	1	1	1	...	...	...	...	...	...
,, Conservator of Forests, Hazara Division	1	3	3	1	1	...	20	...	20	20
,, Post Master General, Burma	8	...	...	...	...	3	525	...	525	525
Director, Geological Survey of India	5	4	...	...	...	4	1,660	415	...	415
Director of Land Records and Agriculture, Bengal	2	...	...	...	3	2	1,100	...	1,600	1,600
,, of Archæological Survey of India	2	2	...	...	...	...	...	...	...	...
,, of Military Education in India	12	...	...	10	8	22	8,190	2,170	1,350	3,520
,, of Public Instruction, Bengal	4	...	...	...	...	3	4,770	2,360	...	2,360
Director General of Railways	31	65	71	24	15	28	2,624	500	2,624	3,124
,, ,, Telegraphs	39	7	1	1	21	26	12,737	...	15,201	15,201
District Staff Officer, Bangalore	...	...	8	1	1	...	100	...	100	100
,, ,, ,, Lucknow	1	...	...	1	1	...	350	...	350	350
,, ,, ,, Secunderabad	2	4	4	2	...	...	...	...	...	...
Engineer-in-Chief, Frontier Railway Survey	...	...	...	1	2	...	600	...	300	300
,, ,, ,, Kashmere Railway Survey	1	1	1	1	...	...	...	...	...	...
,, ,, ,, Mogul Sarai, Howrah Railway Survey	2	...	...	2	2	2	418	105	104	209
,, ,, ,, Mu Valley State Railway	14	14	14	4	5	...	500	...	1,500	1,500
,, ,, ,, Rajputana and Malwa Railway Survey	30	51	51	16	16	...	800	...	1,500	1,500
Executive Engineer, Sitamarhi Extension	...	...	...	...	4	...	400	...	800	800
,, ,, Tirhoot	8	7	7	4	...	...	...	...	...	...
Financial Commissioner, Burma	2	12	12	6	6	...	300	...	300	300
,, ,, Punjab	2	...	...	...	2	...	530	530	...	530
General Officer Commanding, Oudh Division	1	4	4	1	1	...	300	...	300	300
,, ,, ,, Quetta District	1	...	...	...	2	1	395	...	395	395
,, ,, ,, Rawal-Pindi District	3	...	...	...	...	3	275	...	275	275
,, ,, ,, Secunderabad District	...	...	...	...	2	...	300	...	300	300
,, ,, ,, Sirhind District	1	1	1	1	1	...	110	...	110	110
General Superintendent, Horse Breeding Operations in India	2	...	...	...	...	6	465	155	...	155
Government of India, Revenue and Agricultural Department	33	37	2	2	1	5	2,552	505	27	532
,, ,, Foreign Department	70	8	8	4	5	7	986	...	1,735	1,735
,, ,, Finance Department	2	...	...	...	...	2	804	...	804	804
,, ,, Home Department	12	8	12	6	5	...	335	...	1,463	1,463
,, ,, Military Department	26	2	2	1	1	9	645	...	1,895	1,895
,, ,, Public Works Department	75	83	83	24	61	13	34,138	56	82,683	82,739
,, Bengal, Public Works Department	19	...	...	...	8	18	8,600	3,274	1,285	4,559
,, ,, Revenue and General Department	7	5	5	19	26	9	45,570	26,385	12,225	38,610
,, North-Western Provinces and Oudh, P.W.D.	56	72	50	19	15	1	3,895	...	7,630	7,630
,, ,, ,, ,, Revenue	3	2	2	4	8	...	575	...	2,315	2,315
,, Punjab, Public Works Department	26	35	35	12	17	5	7,580	...	13,080	13,080
,, ,, Revenue Department	1	...	...	...	2	...	600	...	600	600
,, ,, General Department	7	...	...	...	...	10	2,780	1,270	780	2,050
Indian Museum	...	...	...	...	...	...	...	...	...	...
India Office, London	2	5	...	...	...	...	...	...	...	...
Inspector General of Military Works	30	63	63	31	33	...	3,740	50	3,690	3,740
,, ,, Police, Calcutta	4	...	...	...	...	4	1,500	1,500	...	1,500
,, ,, Registration, Bengal	1	...	...	...	...	3	1,200	400	...	400
Manager, N. W. Railway	2	...	...	...	2	2	4,310	...	9,410	9,410
Meteorological Reporter to the Government of India	53	...	...	...	...	24	11,005	1,275	23,610	24,885
,, ,, Government of Bengal	3	...	...	1	1	4	24,174	16	24,150	24,166
Officer Commanding Nerbudda District	1	4	4	...	...	...	...	...	...	...
Photographic Society of India	2	2	2	1	...	...	...	...	...	...
Post Master General, Bengal	2	...	...	...	...	2	510	...	510	510
,, ,, North-Western Provinces	...	...	...	4	6	...	3,000	...	3,000	3,000
Port Commissioners, Calcutta	1	30	30	10	10	...	700	...	700	700
Port Officer and Registrar of Wrecks, Calcutta	10	5	2	2	12	6	1,753	125	1,378	1,503
Private Secretary to the Viceroy	3	3	3	1	...	...	...	...	...	...
Protector of Emigrants, Calcutta	4	...	...	...	...	8	2,272	1,136	...	1,136
Quarter Master General in India	114	71	77	33	34	34	6,603	200	32,835	33,035
Sanitary Commissioner, Assam	2	2	2	...	...	2	500	250	...	250
,, ,, Bengal	21	...	...	2	6	22	11,570	3,771	7,184	10,955
,, ,, Central Provinces	1	...	...	...	1	...	273	...	275	275
,, ,, India	19	5	...	...	...	7	4,260	1,605	2,300	3,905
,, ,, Hyderabad Assigned District	2	...	...	...	...	2	495	...	495	495
Secretary, Defence Committee	3	12	12	3	3	...	600	...	600	600
Secretary to Countess of Dufferin's Fund	4	1	1	...	...	2	3,010	1,505	...	1,505
Superintendent of Army Clothing	2	...	...	1	1	...	50	...	50	50
,, Botanical Garden	...	...	...	...	...	...	...	...	...	...
,, Emigration, Calcutta	2	...	...	...	...	4	...	...	...	...
,, Forest Surveys, India	4	...	...	...	...	12	960	320	...	320
,, Government Printing, India	60	11	11	21	20	6	2,692	...	3,411	3,411
,, Stationery, Calcutta	6	...	...	...	...	6	2,712	...	2,712	2,712
,, Terai district	...	...	...	15	15	...	75	...	75	75
Special work done for trade and private individuals	11	4	14	3	3	5	3444	...	5,254	5,254
Total	1,262	1,051	973	562	681	420	327,819	73,163	354,536	427,699

LITHOGRAPHIC OFFICE.

Departments, &c., during the year 1889-90.

Type Printing.			Silver and other Printing.			Heliogravure and Electrotyping.				Photo-collotype.		Value.			Remarks.
Pages or items.	Pulls.	Copies.	Silver prints.	Blue prints.	Miscellaneous prints.	Heliogravure plates.	Heliogravure prints.	Photo-blocks.	Electrotypes.	Photo-collotype plates.	Photo-collotype prints.	£	s.	d.	
...	...	...	...	...	...	...	...	...	...	...	...	2,992	3	0	Twenty-nine subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	...	...	14	3	0	
...	...	...	...	...	...	...	...	...	...	...	...	115	8	0	
...	...	...	...	1	...	5	2,048	...	...	...	...	533	3	0	
...	...	...	...	...	...	...	...	...	...	...	...	1,244	02	0	
...	...	...	...	...	...	...	...	...	...	...	...	52	8	0	
...	...	...	...	3	...	...	...	...	...	...	...	341	6	0	
...	...	...	...	...	...	...	...	...	...	...	...	227	6	0	
...	...	...	...	...	...	...	...	...	...	...	...	419	12	3	One subject not yet printed.
...	...	...	...	20	...	...	...	...	...	...	...	225	13	0	
...	...	...	...	...	...	...	...	...	...	...	...	7	3	6	
...	...	...	...	...	...	...	...	...	...	...	...	5,278	5	9	
...	...	...	...	...	...	...	...	...	...	...	...	185	12	3	
...	...	...	...	...	...	...	...	...	...	...	...	418	9	0	
...	...	...	...	...	...	...	...	...	...	...	...	147	5	6	
...	...	...	...	...	...	...	...	...	...	...	...	176	9	9	
...	...	...	...	...	...	...	...	...	...	...	...	228	12	0	
...	...	...	...	...	...	...	...	...	...	...	...	244	3	0	
...	...	...	...	...	...	...	...	...	...	...	...	593	14	0	
...	...	...	...	...	...	...	...	...	...	...	...	150	7	0	
...	...	...	...	...	...	...	...	...	...	...	...	5	13	6	
...	...	...	...	...	...	...	...	...	...	...	...	332	2	0	
...	...	...	...	...	...	...	...	...	...	...	...	295	5	0	
...	...	...	...	...	...	...	...	...	...	...	...	4,804	11	3	
...	...	...	...	...	...	...	...	...	...	...	...	18	10	0	
...	...	...	...	...	...	...	...	...	...	...	...	47	10	0	
...	...	...	...	...	...	...	...	...	...	...	...	224	7	0	
...	...	...	...	...	...	2	1,322	...	...	12	2,756	1,040	3	0	
...	...	...	...	...	...	...	...	...	...	...	...	224	15	0	
...	...	...	...	2	...	...	...	...	...	...	...	0	9	6	
...	...	...	...	...	...	...	...	...	...	...	...	1,245	12	9	
...	...	...	...	...	...	...	...	...	...	...	...	149	0	0	
...	...	...	...	...	...	...	...	...	...	...	...	2,079	13	0	Fifteen subjects not yet printed.
...	...	...	...	18	...	...	...	...	...	...	...	2,743	4	3	Three subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	...	...	66	9	9	
...	...	...	...	...	...	...	...	...	...	...	...	64	6	9	
...	...	...	...	...	...	...	...	...	...	...	...	64	13	0	
...	...	...	...	...	...	...	...	...	...	...	...	43	5	6	
...	...	...	...	...	...	...	...	...	...	...	...	15	0	0	
...	...	...	...	...	...	...	...	...	...	...	...	83	12	6	
...	...	...	...	...	...	...	...	...	...	...	...	299	11	6	
...	...	...	...	...	...	...	...	...	...	...	...	918	03	3	
...	...	...	...	...	...	...	...	...	...	...	...	89	13	0	
...	...	...	...	...	...	...	...	...	...	...	...	116	6	6	
...	...	...	...	...	...	...	...	...	...	...	...	275	5	6	
...	...	...	...	...	...	...	...	...	...	...	...	53	4	0	
...	...	...	...	...	...	...	...	...	...	...	...	422	0	0	
...	...	...	...	...	...	...	...	...	...	...	...	253	6	0	
...	...	...	...	...	...	...	...	...	...	...	...	564	8	0	
...	...	...	...	...	...	...	...	...	...	...	...	54	0	0	
...	...	...	...	...	...	...	...	...	...	...	...	38	4	0	
...	...	...	...	...	...	...	...	...	...	...	...	186	13	0	One subject not yet printed.
...	...	...	4	30	...	17	16,592	...	...	...	...	3,607	7	9	
...	...	...	75	6	...	...	...	...	...	...	...	458	9	9	
...	...	...	...	...	...	...	...	...	...	...	...	153	13	0	
...	...	...	...	...	...	...	...	...	...	...	...	175	10	6	
...	...	...	40	...	...	...	...	...	...	...	...	454	7	0	
...	...	...	...	...	...	...	...	...	...	...	...	9,132	9	0	
...	...	...	...	...	...	...	...	...	...	...	...	723	12	9	Three subjects not yet printed.
...	...	...	...	74	...	...	...	...	...	...	...	2,093	5	9	
...	...	...	...	...	...	...	...	...	...	...	...	1,715	7	3	
...	...	...	...	...	...	...	...	...	...	...	...	145	3	0	
...	...	...	...	...	...	...	...	...	...	...	...	4,632	12	9	One subject not yet printed.
...	...	...	...	...	...	...	...	...	...	...	...	188	10	6	
...	...	...	...	...	...	...	...	...	...	...	...	681	4	0	
...	...	...	...	...	...	...	400	...	...	...	616	222	10	0	
...	...	...	...	...	...	2	526	...	...	...	...	174	12	0	
...	...	...	...	...	...	...	...	...	...	...	...	1,515	8	3	
...	...	...	...	...	...	...	...	...	...	...	...	109	8	0	
...	...	...	...	...	...	...	...	...	...	...	...	65	15	0	
...	...	...	...	...	...	...	...	...	...	...	...	326	7	0	
...	...	...	...	...	...	...	...	...	...	...	...	2,409	0	0	
...	...	...	...	...	...	...	...	...	...	...	...	365	14	0	
...	...	...	...	...	...	...	...	...	...	...	...	46	13	0	
...	...	...	...	...	...	1	2,002	...	...	...	...	96	0	0	
...	...	...	...	...	...	...	...	...	...	...	...	330	9	0	
...	...	...	...	...	...	...	...	...	...	...	...	534	3	6	
...	...	...	...	...	...	...	...	...	...	...	...	735	1	6	
...	...	...	...	...	...	2	1,002	...	...	...	...	786	12	9	
...	...	...	...	...	...	...	...	...	...	...	...	39	9	6	
...	...	...	...	...	...	...	...	...	...	...	...	226	2	0	
...	...	...	6	32	...	2	411	...	...	...	...	4,342	2	0	Twenty subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	...	...	88	15	6	
...	...	...	...	...	...	...	...	...	...	...	...	2,892	8	0	
...	...	...	...	...	...	...	...	...	...	...	...	36	13	0	
...	...	...	...	...	...	5	2,109	...	...	...	...	1,663	8	0	
...	...	...	...	...	...	...	...	...	...	...	...	82	12	0	
...	...	...	...	...	...	...	...	...	...	...	...	313	12	0	
...	...	...	...	...	...	1	2,505	...	...	...	...	409	8	0	
...	...	...	...	...	...	...	...	...	...	...	...	42	11	3	
...	...	...	...	...	...	...	55	...	...	...	...	12	8	0	
...	...	...	...	...	...	...	...	...	...	...	...	39	7	0	
...	...	...	...	...	...	...	...	...	...	...	...	1,458	4	0	
...	...	...	...	...	...	...	...	...	...	...	...	644	7	3	Four subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	...	...	292	8	0	
...	...	...	...	...	...	...	005	...	...	...	...	60	12	0	
...	...	...	...	2	...	...	...	...	...	...	...	295	14	3	
...	...	...	125	178	...	37	28,172	...	...	12	3,372	69,938	8	0	

MATHEMATICAL INSTRUMENT OFFICE.

TABLE A.

Detail of Issues to and Receipts from Provinces and Departments during the financial year 1889-90.

PROVINCES AND DEPARTMENTS.	RECEIPTS. Value.	ISSUES. Value.	DEBITS. Value.	CREDITS. Value.
	₹	₹	₹	₹
Archæological Survey	...	16	16	
Assam	214	1,989	1,775	
Bengal, Civil	26,764	36,633	9,869	
„ Military	4,383	14,347	9,964	
Bombay, Civil	...	881	881	
„ Military	45	1,826	1781	
Burma	4,787	40,264	35,477	
Central India	188	1	...	187
Central Provinces	53	7,937	7,884	
Foreign States (Berar)	162	1,208	1,046	
Forests	457	2,599	2,142	
Geological Survey and Museums	103	469	366	
Guaranteed Railways, E. I. Railway	559	3,323	2,764	
„ „ Rajputana-Malwa Railway.	...	91	91	
Political	...	6,652	6,652	
Hyderabad, P. W. D.	...	161	161	
Law and Justice (Port Blair)	7	42	35	
Land Revenue, Coorg and Ajmere	...	6,977	6,977	
Madras, Civil	1,434	12,157	10,723	
„ Military	4,113	3,811	...	302
Marine	38	525	487	
Meteorological Department	491	1,530	1,039	
Mint	2,587	108	...	2,479
N. W. P. and Oudh	...	1,898	1,898	
N. W. State Railway, P. W. D.	242	500	258	
P. W. D., Military Works	2,546	7,980	5,434	
P. W. D., Coorg	...	41	41	
Post Office	...	15	15	
Punjab	6,848	21,466	14,618	
Rajputana and Central India, P. W. D.	...	298	298	
Survey of India (Minor Departments)	2,068	3,575	1,507	
Survey Department	31,551	89,008	57,457	
Sind-Pishin State Railway, P. W. D.	50	66	16	
Telegraph Department	1	385	384	
TOTALS	89,691	2,68,779	1,82,056	2,968
NET DEBIT	...	...	1,79,088	

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B.

Instruments, &c., purchased in the Local Market during the financial year 1889-90.

PARTICULARS.	Number.	Value.
		R *a.*
Instruments.		
Altazimuth pocket instruments	4	440 0
Bars, standard, steel	10	326 0
Boards, drawing, cavalry	6	196 8
Chains, iron, 66′	89	756 8
„ steel	5	51 8
„ iron, 100′	46	460 0
Clinometers	16	315 8
Compass, beam tubular	1	45 8
Compasses, bow, dividers, electrum spring	50	100 0
„ „ pencils „ „	50	100 0
„ drawing, common, brass, 5″	1,552	1,532 0
„ prismatic, card, 2″+2½″	3	90 0
„ surveying, Bengali	25	300 0
Glasses, binocular, small	6	360 0
Hydrometers with brass floats	25	1,078 8
Instruments, drawing mathematical, brass, 1st sort	11	643 8
„ „ electrum „ „	12	1,021 4
„ „ „ 2nd „	11	514 4
Lenses, reading, 1½″	150	206 4
Machines, map printing, Ordnance	9	382 8
Pens, drawing, common, ivory handles	200	450 0
„ „ double or road	24	132 0
Pentagraphs, English, 2′	3	339 8
„ „ 2½′ „	2	306 0
„ French	3	918 0
Pins for chains, common pattern	500	31 4
Plane-tables, deal	208	1,564 0
Planimeters, electrum	28	1,515 0
Protractors, rectangular, brass 6″	25	181 3
„ „ electrum, 6″	70	635 0
„ „ ivory, 6″	265	911 7
„ „ wooden, 6″	24	36 5
Rods, measuring, wooden	50	75 0
Rules, flat, ebonite, 6″	250	112 8
„ „ „ 1′	1	0 12
„ parallel, bar, wooden, 6″	325	263 12
„ „ on rollers, brass, 18″	1	29 12
„ sight, for plane-tables	500	1,500 0
„ „ brass, for military plane-tables	1	20 0
Scales, architects', box-wood, sets	3	81 0
„ diagonal, electrum, 6″=5 chains and 2½ chains=1 mile	2	58 0
„ offsets, single, wooden	192	24 0
„ plotting, sets „	14	196 0
„ „ single „	206	345 7
Squares, optical	100	650 0
„ set, ebonite, single	2	6 0
Stands for compasses, surveying, Bengali, M. I. D. make	25	100 0
„ „ plane-tables	602	4,214 0
„ „ theodolites	2	150 0
Staves, levelling, telescopic, Sopwith's	4	64 0
T squares, metal of sizes	3	51 6
Tape, measuring, metallic 120′	1	13 1
„ „ steel, 100′	1	28 12
Theodolites, with V. C., 6″, transit	2	990 0
Thermometers, chemical or traveller	4	22 0
„ spare, for Sykes' hydrometers	74	147 2
Watches, common	25	250 0
TOTALS	5,823	25,331 15

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B—*continued.*

Instruments, &c., purchased in the Local Market—continued.

PARTICULARS.	Number.	Value.
		R *a.*
Books.		
Hints to Travellers	12	49 14
Loomis' Treatise on Astronomy	1	6 10
Nautical Almanacs	88	177 6
Optics, Parkinson's	1	7 0
Schwindler's Testing Instruction	2	13 4
Tables for Barometrical Heights by Mackesy	15	30 0
„ for Hydrometers, Sykes'	20	55 0
„ for Log. Chambers'	6	17 2
„ „ Shortrede's, with Sines and Tangents	7	141 12
„ Traverse, Boileau's	30	246 0
TOTALS	182	744 0
Sundries.		
Boxes for standard yards	62	62 0
Brushes for stencil plates	6	1 6
Canvas bags, water-proof, lined	58	302 0
Cases, leather	154	463 12
Colour-box, Engineer's	1	8 0
Covers, umbrella	6	4 8
Covers, quilted, for box	9	18 12
Durrie	1	7 14
Electros for instruments	48	354 8
Electro-plate badges	36	36 0
Gillott's litho. pens	Dozen 1	1 6
Glasses for pluviometers	68	305 0
„ ink bottles	120	20 7
„ jar for hydrometers	100	137 8
Grademeter, Fairley's patent	1	28 12
Havresacks	12	10 8
Hedley's dial, fitted, &c.	1	252 12
Locks, brass	6	5 10
Nest of saucers	1	2 4
Numbers for chains	1,268	289 10
Parkin's improved oven thermometer	1	46 0
Screw box and tap, 1″	1	4 12
„ „ „ 1½″	1	7 10
„ „ „ 2″	1	12 6
Shots, steel	50	8 4
Silk, oil	sq. ft. 1	0 12
Spectacles, neutral tint	4	5 12
Stencil plates	38	27 12
Talc squares	978	84 12
Tape box hangings	10	7 8
Tarpaulins	2	44 15
Trunks, mule, leather	12	174 0
Umbrellas, surveying	43	692 0
Washers, India-rubber	12	0 9
TOTAL SUNDRIES	3,113	3,429 9
„ BOOKS	182	744 0
„ INSTRUMENTS	5,823	25,331 15
GRAND TOTALS	9,118	29,505 8

MATHEMATICAL INSTRUMENT OFFICE.

TABLE C.

List of Instruments, &c., manufactured in Workshop during the financial year 1889-90.

Instruments.	Number.	Value. £	s.
Bars, standard, steel	10	350	0
Boards, drawing, deal, large	13	180	0
" " " small	1	2	8
" " teak, large	4	48	0
" " " small	2	12	0
Chains, iron, 66′	767	6,458	8
" steel	26	258	0
" iron, 100′	201	1,898	0
" other sizes and sorts	16	98	0
Clinometers, survey pattern	48	1,440	0
Combs, acre calculating, cardboard	3,744	1,379	0
Compasses, magnetic, for plane-tables, 5″	124	1,584	0
" " " " 6″	59	826	0
" prismatic, S. R., 4″	2	90	0
" " " 2½″	2	50	0
Curves, railway, single circular pear wood	8	10	0
Glasses, copying or tracing	12	442	0
Hold-alls	55	1,018	0
Hydrometers, with glass floats	2	47	12
Hygrometers, Mason's	1	22	8
Lamps, bull's eye	24	119	0
Levels, field service	7	140	0
Pins for maps, brass	500	31	4
Plane-tables, deal	408	3,210	0
" " military pattern	6	24	0
" teak	7	64	0
Pluviometers, Symon's	25	200	0
Protractors, cardboard, 12″	100	125	0
Pins for chains, common pattern	9,740	622	8
Rods, measuring, wooden	178	362	0
Rules, flat, wooden, 1′	50	18	12
" " " 2′	30	18	12
" parallel, on rollers, brass, 12″	12	192	0
" sight, brass, for military plane-tables	38	602	0
Scales, diagonal, cardboard	2,350	503	2
" " electrum, 2″=5 chains, &c.	25	100	0
" engineering, cardboard, single	880	238	12
" offsets, single, ivory, and slips	330	139	10
" " " metal	6	15	0
" " " wooden	290	41	14
" plotting, single, metal	7	41	8
" " " wooden	14	26	8
Squares, set, ebonite, sets	3	15	0
" " " single	18	24	0
" " wooden	30	30	0
Staves, cross or offsets	112	560	0
" for omnimeters	13	315	0
" " subtense theodolites and compasses	6	115	0
" levelling, Roorkee pattern, single	12	168	0
" " " " double	12	288	0
" " telescopic, Sopwith's	32	512	0
Stamps for conventional signs and type-holders	10	21	0
Stands for compasses	2	26	0
" " plane-tables	6	42	0
" " telescopes	1	35	0
" " theodolites	5	130	0
" " " universal	6	210	0
Theodolites, Everest's, with V. A. R. S., 5″	2	340	0
Yards, standard bar	198	990	0
TOTALS	20,592	26,874	14

MATHEMATICAL INSTRUMENT OFFICE.

TABLE C—*continued.*

List of Instruments, &c., manufactured in Workshop, &c.—continued.

	Number.	Value. R	Value. a.
Sundries.			
Apparatus for dividing and comparing standard yards	1	160	0
Badges, zinc	500	23	7
Baths, teakwood	10	120	0
Blotters	3	3	6
Boxes and cases, block-tin and tin	19	48	2
Box, mahogany	1	40	0
Boxes for sight rules	41	69	8
Cases, chamois leather for bow sets	22	9	8
„ leather, for barometer	1	75	0
Canvas bags, water-proof, lined	38	184	0
Compass, prismatic, S. R., 3″, with level combined	1	120	0
Die chucks, &c.	12	140	0
Doolies	15	26	4
Girder tester	6	300	0
Glasses for pluviometers (graduations engraved)	12	48	0
Hammers	20	20	0
Handles, brass	16	37	8
„ for chains	40	17	8
Jafferie work for compound	3	200	0
Line-divider, electrum	1	32	0
Links for chains and rings for chains	500	7	8
Numbers for chain, brass, set	1	1	0
Oil cup	1	15	0
Padded boards for thermometers	12	30	0
Plummets, brass	8	10	0
Photographic washing trays	4	128	0
Printing frames	3	102	0
Reflectors for theodolites	4	10	0
Rings for chains	150	1	12
Scale, electrum, 12′, French and English	1	7	8
„ sliding, brass, in box	1	32	0
Staff, subtense, 20′	1	20	0
Stand for heliograph	1	12	8
„ for lenses reading	1	6	0
Screw-driver	2	2	0
Squares, acre, horn	81	62	12
Stencil plates	144	162	9
Tables for comparators	1	17	8
Table, teakwood with drawers	1	20	0
Talc squares	100	9	0
Tickets, brass, for *khalásis*	4,650	216	11½
Trestles, wooden	3	45	0
Tubes, tin and zinc, in wooden cases	32	21	3
Turn-screw	3	1	8
Whatnot, with three shelves	1	5	0
Cases, packing	529	1,301	0
TOTAL SUNDRIES	6,997	3,922	10½
„ INSTRUMENTS	20,592	26,874	14
TOTALS	27,589	30,797	8½
Castings, brass R2,415			
Gun metal R 60	...	2,500	0
Hooks, brass R 25			
Packing cases from 1st December 1889 to 31st March 1890 not included	...	748	12
GRAND TOTALS	...	34,046	4½

MATHEMATICAL INSTRUMENT OFFICE.

TABLE D.

List of principal Instruments repaired in Workshop during the financial year 1889-90.

	Number.
Anemometers	24
Automatic counters	4
Barograph	1
Barometers, of sorts	60
Binnacles, boat	5
Bridge, girder testing machine	1
Camera	1
Chains, of sorts	57
Chronographs, of sorts	3
Chronometers	8
Chronomicrometers	4
Circumferenter	1
Clinometers	14
Clocks, of sorts	3
Compass, azimuth	1
„ beam	1
„ bow pens, of sorts	43
„ „ pencils	9
„ „ „ spring	5
„ „ „ „ dividers	2
„ clinometer	1
„ drawing, of sorts	296
„ liquid	1
„ magnetic for plane-tables, &c,	50
„ „ pocket or watch pattern	13
„ marine	1
„ Pelorus	2
„ prismatic, of sorts	112
„ proportional	6
„ surveying, of sorts	19
„ tell tale	1
Flexure testing apparatus	1
Glasses, binocular	32
Hand presses	6
Heliographs	27
Heliotropes	8
Horizon, artificial	3
Hydrometers	88
Hygrometers	11
Instruments, drawing, mathematical, of sorts	32
Lamps, hand-signalling	2
Lenses, of sorts	17
Levels, Abney's	5
„ of sorts	84
„ spirit	10
Machines, map printing, of sorts	1
Magnets	3
Microscopes	3
Pedometers	2
Pens, drawing, of sorts	130
„ double or road	1
Pentagraphs	10
Perambulator	1
Pins for chains	20
Plane-tables	19
Planimeters, of sorts	10
Pluviometers	15
Protractors, rectangular	11
„ Sandhurst	2
Carried over	1,303

MATHEMATICAL INSTRUMENT OFFICE.

TABLE D—*continued.*

List of principal Instruments repaired in Workshop, &c.—continued.

	Number.
Brought forward	1,303
Quadrant, gunner's	2
Quintant	1
Range finders, of sorts	71
Rules, of sorts	35
„ sight for plane-table	48
Sand glass	1
Scales, of sorts	13
Sector, ivory	1
Sextants, of sorts	10
Squares, optical	199
„ set, wooden, single	20
Stands for camera	4
„ „ compasses, of sorts	54
„ „ heliographs	18
„ „ levels	44
„ „ plane-tables	21
„ „ range finders	2
„ „ telescopes	1
„ „ thermometers	16
„ „ theodolites	40
Station pointer	7
Staves, levelling, of sorts	150
Sun-dials	4
Tapes, of sorts	142
Telescopes, of sorts	112
Theodolites, of sorts	83
Thermometers, of sorts	101
Watches	4
TOTAL OF PRINCIPAL INSTRUMENTS REPAIRED	2,507
„ MINOR INSTRUMENTS REPAIRED	597
TOTAL OF ALL INSTRUMENTS REPAIRED	3,104

Profit and Loss account of the Workshop for the financial year 1889-90.

Debits.	R	a.	Credits.	R	a.
Workshop establishment, less proportion debitable to the Store Branch for cleaning and adjusting serviceable instruments	34,454	7	By repairs for public officers	12,308	14
			„ „ inter-departmentally	...	
			„ „ for stock	28,920	10
			„ manufactures for stock—Instruments	29,733	4
			Packing cases	2,076	0
One-third of office Establishment	2,373	11	„ manufactures for materials	2,500	0
Pay of Material Store-keeper for the whole year	780	0			
Workshop contingencies, as distinguished from materials purchased	3,041	8	Work on prepayment	1,314	15
Value of materials—			Value credited to Government for boiler made over to the Superintendent, Calcutta Workshops Division (*vide* his letter No. 1459, dated 28th July 1890, and M. I. O. letter No. 3816, dated 2nd August 1890)	80	0
For special work	25,536	4			
„ general workshop use					
„ manufacture of packing cases					
Paid for repairs	1,167	1			
Wear and tear of plant	2,270	10	Value credited to Government for implements and tools sold by P. W. D. (*vide* letter No. 539, dated 25th February 1890, from Executive Engineer, 2nd Calcutta Division)	155	9
Half of rent at R600 per mensem	3,600	0			
Printing and stationery	392	2			
Four per cent. on value of tools and plant, amounting to R89,111	3,564	7			
Value of boiler made over to P. W. D. for sale	200	0	Value credited to Government for old furnace sold	1	12½
Value of implements and tools made over to P. W. D. for sale	424	0			
			Loss	1,213	5½
Total	77,804	2½	Total	77,804	2½

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Extract from the Narrative Report of MR. W. H. COLE, M. A., *in charge Computing Party,—Season 1889-90.*

All the sections of this office have been under my charge throughout the year, except the Drawing and Correspondence sections; the former was chiefly occupied in the compilation of trans-frontier maps, and was under Major Gore's superintendence till 15th October 1889, when he was transferred to Calcutta, and its charge was added to my other duties until Colonel Holdich was available to relieve me in February 1890. The Drawing section was then divided into two parts, one of which formed the Simla detachment and was transferred to that place under Colonel Holdich, and the other continues at Dehra and is chiefly employed on work connected with the publications of this office.

Mr. E. C. Ryall was appointed to do duty with the office until his retirement on the 25th September 1890. Lieutenant C. F. Close, R.E., was also appointed to do duty with the office on being transferred to the Trigonometrical Branch, from 1st August to 7th September 1890, when he took over charge of No. 24 Party from Mr. Eccles, who was then transferred to this office. Mr. C. Wood, who had been for so many years connected with the office, was promoted to the Senior Division on the 3rd December 1889, and posted to the charge of No. 25 (Tidal and Levelling) Party; Mr. H. G. Shaw, who was transferred to No. 14 Party on 1st October 1889, was re-posted to this office on 1st July 1890.

When the Simla detachment of the Drawing office was transferred, Messrs. Atkinson, Gwynne, Cornelius and Kitchen were transferred with it, and also three draftsmen and eight assistant draftsmen.

Mr. Ollenbach, who had been many years zincographer in the Photo-zincographic office, retired on his pension on the 31st December last.

Towards the close of the year ten temporary computers were added to the Computing staff in accordance with the wishes of the Government, to aid in expediting the work still remaining to be done.

The following tabular statements exhibit the money value of the work performed by the Computing section during the year under review:—

Statement of Expenditure (Dr.) and amounts credited (Cr.)

DR.			CR.		
	R	R		R	R
Deputy Superintendent's salary.	8,620		Departmental work, as shown in the following table . .	41,044	
Establishment	32,284				41,044
Contingencies and travelling allowances	795		Extra-departmental work done .	780	
		41,699			780
Stores received from England .	20				
		20			
Stationery	75				
		75			
Library, books and periodicals .	30*				
		30*			
TOTAL .	...	41,824	TOTAL .	...	41,824

* Freight and other small charges for books; the price of books and periodicals is omitted, as these are now received from the Stationery Office.

Statement of Departmental Work.

Class.	Value.
	R
Records, Library (including cost of purchase of books,* &c.)	1,572
Computations	10,015
Accounts, returns, correspondence	2,150
Supply of data, &c.	932
Preparation of press copy	10,072
Examination of press proofs	7,498
Examination of charts, &c.	639
Protection of stations	612
Miscellaneous	7,007
Meteorology and General Science	547
TOTAL	41,044

* Excepting those supplied through the Stationery Office.

Statement showing the value of work done for other Departments.

Department.	Value.
	R
Meteorological Department	230
Quarter Master General's Department	550
TOTAL .	780

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

The preceding statements afford a fair idea of the cost of the work performed under the various classes; but some explanation of these is necessary, and will now be given.

CLASS 1. RECORDS, LIBRARY, &C.—The records of all the Survey operations appertaining to the Trigonometrical Branch, from the time of Colonel Lambton to the present date, find a resting-place in this office, where they are carefully stored and periodically inspected. Further, as each fresh instalment is received, it is closely examined, indexed, registered, and a detail receipt furnished to the executive officer from whom it comes. During the past year records have been received from four field parties, and have been dealt with in the manner above described. The custody of the library, which now contains over four thousand books and pamphlets, chiefly of a scientific character, also comes under this head, as well as the cost of books purchased during the year, both for the library itself and also for the several Survey parties of the Trigonometrical Branch.

The scientific periodicals received by this office are now supplied by the Stationery Office, and the charge for them does not appear in the foregoing statements.

CLASS 2. COMPUTATIONS.—The duty of this office, as already stated in previous reports, is the final reduction and publication of the operations of the Trigonometrical Branch. These operations consist of the execution of series of triangulation, in the taking of astronomical observations, and in the carrying of lines of spirit-levels over the country. Primary reductions are made in the offices of the parties which execute the several works, in order to present each complete in itself; but a great deal then remains to be done, before those works can be presented to the public, and it is necessary to fuse into a harmonious whole all the various geodetic operations: to effect this, very intricate calculations are required, and they form the main work of this office. Under this head, and for the year under report, the following may be specially mentioned:—

(*a*) *South-West Quadrilateral.*—The adjustment of the heights of the principal stations of the Guzerat Longitudinal, the Khanpisura, Singi and Abu Meridional, and the Cutch Coast Series, has been completed: this finishes the reduction of the principal triangulation of this quadrilateral. The reduction of the secondary work has been begun, and the following shows the progress made:—

One thousand triangles have been selected, and their data copied. Log sines of 800 have been computed, of which 84 have been adjusted, and the latitude, longitude and azimuth of 35 points have been deduced.

(*b*) *North-East Quadrilateral.*—All the computations appertaining to that portion of the Assam Longitudinal Series which lies to the east of the 92° meridian, and the results of which are arranged to be published in Degree Sheets Nos. 13 to 28 have been completed; those appertaining to the western portion are still in abeyance, pending the receipt of data of snow-peaks awaited from the Himalaya party.

(*c*) *Southern Trigon.*—Very considerable progress has been made with the reduction of the secondary triangulation, including Lambton's work. The work has been divided into seven sections for publication, of which that appertaining to the South Konkan Coast Series stands completed, and that for the other series is well advanced. The calculations done are as follows:—

Triangles adjusted and computed	1,187
Latitude, longitude and azimuths computed	1,314

In addition, the heights of the principal stations of the Madras Meridional and Coast, and of the Madras Longitudinal Series, were adjusted and finally reduced. This completes all the calculations of the principal triangulation embraced in the Southern Trigon, and which forms the subject of Professional Volumes XII and XIII, now in the hands of the binder.

(*d*) *East Coast Secondary Series.*—Computed heights of stations and intersected points for charts Nos. 7, , 89 and 15.

(*e*) *Extra-Departmental Work.*—Two computers were engaged for two and three-quarter months in reducing astronomical, barometrical and hypsometrical observations taken in Persia and elsewhere, for the Quarter Master General's Department.

(*f*) The following assistance was rendered to field parties:—

Two computers were lent for about five months to the astronomical parties for reduction of electro-telegraphic observations, season 1889-90, and one computer was engaged for one and a half months in bringing up certain work of the Tidal and Baluchistan parties.

(*g*) Spirit-levelled heights for pamphlet No. 5, Madras Presidency, were revised: the remaining work performed under this class was of a miscellaneous character.

CLASS 3. ACCOUNTS, RETURNS AND CORRESPONDENCE.—Under this head are included indents, estimates, monthly detailed and abstract progress reports, stock returns of ordnance stores, the compilation of data for the Annual Report, and various other items. The assistance rendered in the current work of the Deputy Surveyor-General's Office is also included in this class.

CLASS 4. SUPPLY.—Requisitions from officers for data of various kinds have been complied with. In this class is also included the cost and labour in the despatch of maps, charts, books and forms.

CLASS 5. PREPARATION OF PRESS COPY.—This consists in the writing of the letter-press for the several publications; also in abstracting and compiling the results of the various calculations in a suitable form for publication. All tabular data, when so com-

piled, are carefully compared twice, before handing to the printer. The details of the work are as follow :—

(*a*) *Southern Trigon.*—The abstracts of heights of the principal stations of the Madras Meridional and Coast and of the Madras Longitudinal Series were completed. Introductory Chapters III and IV, as well as the prefaces, tables of contents, &c., of Professional Volumes XII and XIII, were compiled and finally passed for press. As regards the matter for the Synoptical Volumes, very considerable progress has been made during the year in revising and compiling details appertaining both to the secondary triangulation of the modern survey and that of Colonel Lambton's net-work. The Synoptical Volume of the South Konkan Coast Series has been completed; the co-ordinate lists of the Mangalore Meridional Series and of the South-East Coast Series are well advanced, while that of the Madras Longitudinal Series may be considered about one-third compiled; so that there still remains a great deal of work to complete these lists as well, as those for the remaining series of the Southern Trigon.

(*b*) *South-West Quadrilateral.*—The introductory chapters for Part I of the Professional Volume of this Quadrilateral, which will be Volume XIV, have been completed. In Part II the introduction to the Guzerat Longitudinal Series has been revised and finished: the abstracts of heights of the Khánpisura, Abu and Singi Meridional Series and of the Guzerat Longitudinal and Cutch Coast Series, as well as all the abstracts of Astronomical Azimuths for the whole of the series, were completed and finally revised for the press. To complete this publication, there remains only the description of stations of the Singi Meridional Series, which is still in hand. The secondary triangulation, the details of which will be embodied in Synoptical Volumes, was taken up, and the triangles arranged and transcribed in part, but the work had to be put aside in order to press on with similar work in the Southern Trigon, which was more advanced and was required to feed the press.

(*c*) Letter-press for the Coast Series charts Nos. 7, 8, 9, 12 and 13, has been revised and completed.

(*d*) *Spirit-levelling Operations.*—The pamphlet of heights, No. 5 Madras Presidency, was revised and passed through the press.

(*e*) *Astronomical Latitudes.*—The last two tables of Part II of Professional Volume XI, as well as the remaining pages, such as the table of contents, &c., were revised and passed through the press.

(*f*) *Hand-book of the Trigonometrical Branch.*—Pages 36 to 180 were examined, revised, and passed through the press.

(*g*) *Hand-book of the Topographical Branch.*—Pages 1 to 88 were examined, revised, and passed through the press.

CLASS 6. PRESS PROOFS.—The work done under this heading relates entirely to the Printing section. It consists of the examination and comparison of proofs. As most of the matter printed is numerical, or depends on numerical data, this examination can only be performed by men thoroughly acquainted with all the details of the subject in hand. Ordinary press readers could not be expected to render the critical examination which such matter requires. The charge for this class, though shown against the computing section in order to balance the cost, is debited against the Printing section. The printing of the following works was completed during the year and sent to the binder :—Professional Volumes XI, XII and XIII, and Pamphlet of spirit-levelled heights, No. 5, Madras Presidency.

CLASS 7. CHARTS.—The careful examination of all the charts of triangulation and spirit-levelled heights before publication is a matter of much importance, and this work is also performed by the Computing section, where the familiarity with the original records renders the detection of mistakes much easier and more certain than if the examination were made by the draftsmen themselves. The principal subjects examined were the reduction chart of the Southern Trigon for Professional Volumes XII and XIII, Degree sheets Nos. 13 to 28 for the Synoptical Volume of the Assam Longitudinal Series (preliminary issue), the final chart of the South Konkan Coast Series for the Synoptical Volume, and the chart to accompany the pamphlet of levels in Madras, entitled "No. 5, Madras Presidency," also several other items.

CLASS 8. STATIONS.—The necessary professional aid in connection with the protection of survey stations has been rendered by the Computing section to the office of the Deputy Surveyor-General. During the year under report, 911 stations have been repaired by district officers at a cost of ₹3,190. Twenty-four districts, out of 329 from which reports are due, failed to submit them.

CLASS 9. MISCELLANEOUS.—In this class are included various other duties of the Computing section, which cannot fairly be assigned to any of the other classes, such as the following :—

(*a*) The current observatory work at Dehra; the rating of the chronometers; the cleaning and keeping in order of instruments of the larger class, etc.; (*b*) the taking and reducing of time observations at Mussooree, in order to give time for the 12 o'clock gun; (*c*) the examination of four candidates for the junior branch of the department; (*d*) the instruction of Lieutenants Markham and Vaughan in astronomical observations for time, latitude, and azimuth; and (*e*) assistance rendered to the Deputy Surveyor-General on a variety of professional and official points.

CLASS 10. METEOROLOGY AND GENERAL SCIENCE.—

Meteorological Observations.—A complete set of meteorological observations was taken daily throughout the year at Dehra, and monthly abstracts prepared. The results are given in the following statements :—

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Mean Monthly Readings of Earth Thermometers.

Depth in feet of thermometer bulbs below surface of ground.	Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
		°	°	°	°	°	°	°	°	°	°	°	°
	1881	...	...	...	...	...	73·55	73·90	75·02	76·07	76·69	76·98	*76·71
	1882	75·91	75·13	74·52	74·11	73·97	74·05	74·31	74·95	75·69	76·14	76·39	76·37
	1883	75·85	75·02	74·28	73·89	73·97	73·96	74·32	74·90	75·66	76·16	76·28	76·12
	1884	75·20	74·39	73·90	73·64	73·63	73·95	74·32	76·00	76·87	†77·33	77·27	76·72
	1885	75·83	74·95	74·34	74·00	73·92	74·02	74·25	‡	‡	‡	‡	‡
25·6 ...	1886	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
	1887	(a)74·58	74·67	74·30	73·80	73·50	73·55	73·95	75·05	76·01	76·20	76·28	76·20
	1888	75·90	75·49	74·87	74·22	73·87	73·83	74·10	(h)75·26	76·44	76·97	77·10	76·87
	1889	76·55	76·00	75·39	74·71	74·25	74·17	74·59	76·63	77·67	77·64	77·49	77·22
	1890	76·79	(i)76·34	75·68	75·15	74·84‖	74·82	75·20	k	(77·68	...	...	...
	1881	...	...	...	...	...	74·87	76·47	77·88	78·98	79·26	77·71	74·89
	1882	72·33	70·79	70·47	71·70	73·37	75·23	76·87	78·20	78·98	79·02	77·64	74·89
	1883	72·46	70·36	69·83	70·94	73·00	75·17	76·82	78·20	78·97	78·93	76·93	73·50
	1884	70·95	69·75	70·04	71·47	73·39	75·75	77·42	79·24	79·82	79·34	§77·08	74·52
	1885	72·18	70·37	70·03	71·14	72·66	73·99	76·09	78·98	79·42	79·25	77·93	75·36
12·8 ...	1886	72·49	(b)70·56	70·26	70·93	72·46	74·12	76·18	78·63	79·54	79·41	77·82	75·16
	1887 Old	(c)72·36											
	1887 New	(d)69·22	68·80	69·67	71·12	73·38	76·09	77·65	79·23	79·77	79·30	77·08	74·10
	1888	72·16	70·87	70·18	70·97	72·87	75·37	77·20	78·94	79·58	79·25	78·27	76·50
	1889	74·25	72·12	70·73	71·25	73·05	75·18	77·27	79·23	80·13	79·78	78·62	76·77
	1890	74·42	72·58	71·16	71·42	73·25	75·26	77·15	80·81	80·81	80·36	79·25	77·55
		75·43	73·79	73·02	72·99	74·58	76·65	78·35	80·46	80·47	...	...	...
	1881	...	...	...	...	...	80·66	81·01	80·75	81·24	80·33	75·80	70·58
	1882	67·17	66·06	67·75	72·29	76·47	80·01	80·78	81·30	81·32	80·16	75·75	71·03
	1883	67·64	65·20	66·48	71·00	76·72	79·29	80·70	81·42	81·12	79·50	74·50	68·71
	1884	66·03	65·61	67·95	72·36	76·99	80·76	81·46	81·64	81·10	78·85	73·81	69·57
	1885	66·64	64·83	66·73	71·10	74·29	77·50	80·32	80·77	80·85	79·90	76·19	70·97
6·4 ...	1886	66·53	64·72	66·61	69·99	74·87	77·87	80·34	81·54	81·70	79·92	75·50	70·69
	1887 ¶Old	65·79	64·16	65·63	71·49	76·96	80·23	80·57	81·08	80·89	79·43	75·33	71·10
	1887 New	(e)64·65	64·54	67·58	71·72	77·91	80·94	80·86	81·21	80·88	79·58	75·94	71·97
	1888	67·67	64·78	67·04	71·91	76·84	80·67	82·13	81·79	81·50	79·50	76·23	71·11
	1889	67·90	66·06	67·03	71·99	77·32	80·30	81·69	82·16	81·64	79·99	77·05	72·89
	1890	69·69	68·20	69·59	73·61	78·66	82·33	82·32	81·39	81·45	...	...	...
	1881	...	...	...	...	...	85·93	83·29	82·03	82·40	79·67	72·20	65·59
	1882	62·87	62·31	67·61	75·49	80·86	84·77	82·71	83·04	82·20	79·21	71·73	66·14
	1883	62·27	60·70	64·83	74·13	81·57	83·44	83·00	83·43	81·74	78·23	69·32	62·50
	1884	61·24	61·90	67·69	76·75	82·32	85·18	84·20	81·94	81·38	76·50	69·32	64·18
	1885	61·38	60·28	65·97	73·52	76·30	82·30	82·68	80·94	81·35	78·73	72·55	65·37
3·7 ...	1886	60·79	60·22	65·33	72·39	78·89	82·14	82·55	82·48	82·37	78·44	71·74	65·56
	1887	(f)61·70	59·99	68·80	76·55	85·47	84·93	82·56	81·63	81·31	78·23	72·08	66·91
		58·57											
	1888	61·77	60·46	67·93	76·58	82·31	86·18	83·84	82·53	82·14	77·40	72·47	65·08
	1889	63·08	61·44	67·15	76·50	82·22	84·71	83·47	82·39	81·58	78·14	73·17	67·55
	1890	64·76	64·86	69·15	77·86	84·03	86·64	83·42	81·14	81·42	...	...	...
	1881	...	...	...	...	...	89·16	84·14	82·55	83·19	77·82	67·81	60·72
	1882	58·01	59·41	69·50	78·88	84·99	88·24	83·48	84·08	82·89	77·85	67·96	62·17
	1883	57·98	58·45	65·87	79·53	86·65	87·94	84·55	84·89	82·39	76·70	65·41	57·83
	1884	58·28	59·89	69·56	80·14	88·27	88·57	85·59	82·03	81·64	74·14	65·38	60·10
	1885	57·35	57·75	68·28	77·20	78·63	87·22	84·35	81·16	82·09	77·45	69·04	60·91
1·1 ...	1886	57·13	57·76	66·25	77·19	83·02	86·44	83·78	82·99	83·16	76·78	68·36	61·20
	1887	55·80	58·16	69·27	79·12	89·25	85·94	82·73	81·34	81·01	75·79	67·54	61·31
	1888	55·79	57·31	(g)67·20 / 71·80	79·87	85·75	89·76	83·34	82·81	80·38	74·47	67·27	57·96
	1889	57·34	57·77	67·87	78·88	84·09	87·94	83·98	82·53	80·84	75·84	68·92	60·72
	1890	58·76	62·47	68·64	81·11	88·72	80·62	84·42	81·54	80·72	...	...	...
	1881	...	...	...	...	...	87·68	82·54	81·00	82·80	82·72	75·22	71·49
	1882	66·77	66·51	81·36	88·72	91·04	83·11	81·61	82·40	84·62	83·47	78·04	74·36
	1883	64·80	68·72	75·89	91·83	95·54	90·60	83·54	83·85	82·86	82·60	70·95	66·42
	1884	67·36	68·52	81·32	89·31	97·33	89·69	83·86	79·73	80·30	77·30	71·77	67·37
Thermometer in shade.	1885	62·50	65·44	79·35	85·63	84·47	91·57	82·74	79·08	82·41	81·98	75·09	68·21
	1886	63·04	67·49	73·74	88·55	87·82	90·60	82·35	81·78	85·05	80·90	74·56	68·93
	1887	59·79	70·64	80·37	89·88	98·66	89·09	81·28	78·60	83·34	80·03	74·73	67·50
	1888	62·74	66·99	81·89	91·99	95·80	96·33	82·21	80·27	84·74	79·53	71·36	67·54
	1889	65·27	65·54	81·04	91·46	93·08	90·18	81·86	81·27	82·12	82·74	76·48	71·35
	1890	67·76	72·81	78·58	91·46	96·58	92·22	80·12	81·01	82·62	...	...	...

* The hole, which had gradually filled up about 2½ feet, was dug down to the original depth between the 20th and 24th December 1881.

† The hole, which had gradually filled up 2 feet since December 1881, was dug down to the original depth between the 9th and 18th November 1884.

‡ Earth fell in from the sides of the hole on the 2nd and 3rd August 1885, and covered the thermometer to the depth of 11 feet. It was found impossible to sink another thermometer to this depth till 20th January 1887, when a new hole was dug down to the depth of 25·6 feet and lined with 4-inch stoneware pipes.

§ The hole, which had gradually filled up 11 inches since June 1881, was dug down to the original depth on the 17th and 18th November 1884.

‖ Mean of 30 days of the month, the instrument being out of order on the 2nd May 1890.

¶ A new hole was dug in January 1887 and lined with stoneware pipes, but the old hole was left undisturbed for the sake of comparing the readings.

(a) This is the mean of the readings of the last 11 days of the month.

(b) When the 25-foot hole filled up in August 1885, the 12-foot hole, which was close by, deepened about a foot, and the length of chain being greater than necessary, the thermometer remained suspended at a depth of 14 feet till 23rd January 1887, when the hole was filled up till it was only 12·8 feet deep. At the same time a new hole was dug to this depth and lined with 4-inch stoneware pipes. Readings from both have been regularly taken for the sake of comparison.

(c) This is the mean of the readings of a 14-feet deep thermometer for the first 23 days of the month.

(d) This is the mean of the readings of a 12·8 feet deep thermometer on the last 7 days of the month.

(e) This is the mean of the readings of the last 7 days of the month.

(f) This is the mean of the readings of the first 13 days of the month, after which a new hole was sunk lined with 4-inch stoneware piping, and the reading below is for the last 14 days of the month.

(g) This is the mean of the readings of the first 20 days of the month, after which a new hole was sunk lined with 4-inch stoneware piping and the reading below is for the last 11 days of the month.

(h) Mean of 25 days of the month, the instrument being out of order from 11th to 16th August.

(i) Thermometer replaced by No. 'O on February 21st, 1890.

k Observation not trustworthy owing to water having percolated into the hole.

l Mean of 28 days of the month, the instrument being out of order on the 1st and 2nd September 1890.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Mean velocity in miles of the Winds which blew at Dehra Dun during the twelve months of 1889-90 for each hour of the day.

Civil Hours.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
0 to 1	1·77	0·59	0·58	0·61	1·32	1·81	1·43	2·04	1·14	0·39	0·16	0·44
1 „ 2	1·35	0·21	0·42	0·55	1·54	1·55	1·47	2·00	1·14	0·32	0·13	0·37
2 „ 3	1·23	0·14	0·32	0·45	1·46	1·23	1·60	1·48	1·18	0·16	0·13	0·22
3 „ 4	0·58	0·10	0·26	0·32	1·29	1·19	1·53	1·33	1·18	0·10	0·19	0·33
4 „ 5	0·52	0·10	0·23	0·13	1·14	1·19	1·17	0·70	0·86	0·03	0·13	0·22
5 „ 6	0·45	0·14	0·13	0·16	1·04	0·84	1·20	1·19	0·64	0·13	0·16	0·11
6 „ 7	0·39	0·10	0·16	0·23	0·89	0·97	1·40	0·96	0·77	0·03	0·19	0·22
7 „ 8	0·13	0·03	0·16	0·32	0·89	0·94	1·17	1·04	0·91	0·16	0·23	0·07
8 „ 9	0·06	0·03	0·13	0·26	0·96	0·87	1·27	1·33	2·00	0·52	0·39	0·15
9 „ 10	0·45	0·03	0·26	0·39	1·14	1·74	2·10	2·11	2·09	0·71	0·65	0·74
10 „ 11	0·29	0·14	0·84	0·81	1·61	2·29	2·63	2·85	2·59	1·16	0·68	0·96
11 „ 12	0·84	0·55	1·03	1·06	2·18	2·81	3·50	3·52	2·91	1·42	1·19	0·81
12 „ 13	1·42	0·90	1·32	0·90	2·71	3·52	4·67	4·22	2·91	1·68	1·42	0·81
13 „ 14	1·29	1·43	1·68	1·32	3·04	3·61	4·40	4·78	3·74	2·00	1·45	1·00
14 „ 15	1·39	0·93	1·61	1·35	3·11	4·39	4·63	5·30	3·61	1·71	2·06	1·04
15 „ 16	1·06	0·90	1·10	1·26	2·75	3·87	3·77	4·26	3·70	1·06	1·61	0·81
16 „ 17	0·29	0·62	0·39	1·10	2·54	3·19	4·00	4·11	3·48	0·90	1·48	0·63
17 „ 18	0·10	0·03	0·16	0·58	1·00	2·10	2·30	4·07	2·61	0·68	0·97	0·19
18 „ 19	0·71	0·03	0·29	0·52	0·29	0·84	1·07	2·44	2·13	0·48	0·55	0·07
19 „ 20	1·32	0·52	0·87	0·45	0·64	0·71	0·93	2·22	2·09	0·42	0·39	0·15
20 „ 21	1·94	0·69	1·10	0·42	1·39	1·26	1·27	2·22	1·32	0·29	0·35	0·19
21 „ 22	2·10	0·97	1·00	0·58	1·43	1·55	1·87	2·00	1·27	0·65	0·35	0·33
22 „ 23	2·00	0·79	0·87	0·65	1·71	2·00	1·80	2·52	0·91	0·39	0·32	0·33
23 „ 24	1·61	0·62	0·90	0·68	1·32	2·03	1·67	2·33	1·05	0·19	0·16	0·74
Sums	23·29	10·59	15·81	15·10	27·39	46·50	52·85	61·02	46·23	15·58	15·34	10·93
Average	0·97	0·44	0·66	0·63	1·14	1·94	2·20	2·54	1·93	0·65	0·64	0·46

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Monthly Meteorological Results taken from the Register

Year and Month.	Barometer reduced to 32° Fahrenheit.						Hygrometer.	
	At 9-30 A. M.			At 3-30 P. M.			At 9-30 A. M.	At 3-30 P. M.
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean humidity.	Monthly mean humidity.
1889.								
October	27·760	27·571	27·657	27·647	27·485	27·583	0·49	0·40
November	·822	·657	·730	·778	·592	·664	0·52	0·38
December	·912	·675	·796	·828	·611	·716	0·48	0·33
1890.								
January	·852	·609	·743	·778	·567	·667	0·59	0·44
February	·880	·475	·742	·769	·431	·624	0·45	0·31
March	·841	·480	·644	·702	·427	·559	0·41	0·26
April	·747	·451	·537	·634	·389	·500	0·32	0·22
May	·581	·319	·482	·491	·287	·397	0·29	0·19
June	·464	·261	·366	·375	·191	·276	0·60	0·46
July	·469	·199	·338	·445	·175	·279	0·85	0·85
August	·528	·405	·460	·498	·281	·409	0·84	0·79
September	·731	·475	·556	·633	·377	·469	0·67	0·76

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

at the Trigonometrical Branch Office, Dehra Dun.

THERMOMETER.								RAIN.		WIND.	CLOUD	
DRY BULB.					WET BULB.							
Maximum on sun's rays.	Minimum on grass.	Maximum in air.	Minimum in air.	Monthly mean in air.	Maximum.	Minimum.	Monthly mean.	Number of days it fell.	Fall in inches.	Most frequent direction.	At 9-30 A. M.	At 3-30 P. M.
142·9	45·3	87·0	54·1	72·2	74·3	49·2	62·1	0	0	N. E.	0	0
136·0	36·7	83·0	45·1	65·6	67·7	41·9	55·9	0	0	Calm	0	0
129·1	30·4	78·3	41·4	59·8	60·0	37·2	50·1	0	0	Calm	1	2
132·8	30·5	75·0	38·8	58·8	62·0	36·8	50·6	5	0·68	Calm	2	3
136·4	33·1	80·7	41·6	62·2	62·1	38·7	51·9	2	0·08	W.	4	4
143·5	41·4	88·9	48·6	67·4	68·2	43·3	54·6	4	0·91	W.	3	4
157·8	48·6	101·5	56·4	69·6	73·7	48·1	60·0	5	0·51	W.	2	4
157·5	58·3	103·5	65·9	83·3	77·5	53·7	65·9	6	0·60	W.S.W.	1	1
155·3	64·0	108·3	66·0	84·2	80·9	60·5	73·0	13	9·82	S.S.E.	6	6
159·6	68·4	91·0	70·3	78·6	85·2	69·9	75·2	28	39·37	S.	8	8
152·8	60·8	88·9	68·8	77 8	81·4	65·2	74·3	22	35·21	S.	7	8
151·2	57·4	89·7	63·2	76·3	79·7	59·7	72·0	11	5·39	Calm	4	5

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

TYPE-PRINTING SECTION.—With the exception of a trifling amount of work done for other departments, the energies of this section have been entirely devoted to the publication of the records of this branch of the Survey Department and work connected with the office.

Hitherto the forms for use with the Tidal and Levelling party were procured elsewhere; but now a proportion of them are printed in this office, and this has thrown a good deal of extra work on the Type section. In order to increase the press power of the branch, a press has been transferred from the Calcutta office, but it has proved so large and heavy that none of the pressmen are strong enough to work it; nor has a man capable of doing so been found as yet.

The following tabular statements show the money value of the work performed by this section:—

Statement of Expenditure (Dr.) and amounts credited (Cr.) during the year 1889-90.

DR.			CR.		
	R	R		R	R
Superintendence	780		Departmental work, letter-press, forms, diagrams, &c.	18,462	18,462
Establishment	8,633				
Aid rendered by Computing section	7,498				
Wear and tear of plant	492				
Contingencies	111	17,514	Extra-departmental work	95	95*
Stores received from England	170	170			
Stores purchased in India	...	...			
Stationery from Stationery Office	873	873			
TOTAL	...	18,557	TOTAL	...	18,557

* This does not include cost of letter-press for maps and charts, such as headings, foot-notes, &c., which has been charged in the Photo-zinco section.

Statement of departmental work done during the year 1889-90.

SPECIFICATION OF PRINT.	Number of pages.	Total number of pulls.	Number of copies.*	Value.
				R
Professional Volumes	791	149,525	510	12,979
Synoptical ,,	2	9,640	360	1,210
Pamphlets of spirit-levelled heights	43	3,700	310	141
Letter-press for charts, map headings and foot-notes	12	916	107	111
Hand-books for the Trigonometrical and Topographical Branches	209	5,080	154	1,681
Forms	189	20,000	150	999
Miscellaneous	200	35,716	Not obtainable.	1,341
TOTAL	1,516†	224,637	...	18,462

* Approximate number.
†Equal to 1,998 pages of standard (foolscap) size.

Statement showing the amount and value of work done for other Departments during the year 1889-90.

Departments.	Number of pages.	Total number of pulls.	Number of copies.	Value.
				R
Forest Department	27	146	146	95
TOTAL	27	146	146	95

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

The usual table showing the work annually performed by this section during the past five years is given below, the unit (a page of foolscap) being the same throughout—

	1885-86.	1886-87.	1887-88.	1888-89.	1889-90.
Pages composed	1,340	1,516	1,994	1,989	1,998
„ printed	638,593	805,076	708,506	782,286	789,265

An analysis of the pages composed is as follows :—

		Pages.
Professional	Longitude operations	94
	Latitude operations	282
	Great Arc Series, section 8° to 18°	3
	Bombay Longitudinal Series	6
	South Konkan Coast Series	9
	Madras Longitudinal Series	36
	Madras Meridional Series	40
	Mangalore Meridional Series	22
	Introductory chapters	493
	Singi Meridional Series	51
	Khanpisura Meridional Series	34
	Abu Meridional Series	12
	Kattywar Meridional Series	42
	Cutch Coast Series	57
	Total	1,181
Synoptical	South Konkan Coast Series	36
	Assam Longitudinal Series	36
	Total	72
Miscellaneous	Hand-books for Trigonometrical and Topographica Branches	209
	Spirit-levelled heights	43
	Letter-press for charts, map heading and foot-notes	12
	Forms, orders, memoranda, &c.	481
	Total	745

PHOTO-ZINCOGRAPHIC SECTION.—This section has been employed in printing maps, charts, diagrams, &c., both to illustrate the volumes published by the office and for general use, also in printing from zinc the departmental professional forms in which mathematical formulæ are largely employed : it has also executed a large amount of extra-departmental work, as will be seen on reference to the second of the following tables ; about one-third the work done has been for other departments.

The following statements exhibit the value and out-turn of work done in this section :—

Statement of expenditure (Dr.) and amounts credited (Cr.) during the year 1889-90.

Dr.			Cr.		
	₹	₹		₹	₹
Superintendence	2,400		Departmental maps, forms, diagrams, &c.	12,959	12,959
Establishment	7,498				
Contingencies	490				
		10,388			
Chemicals and stores from England	1,275				
Paper received from England	1,448		Miscellaneous maps, plans, &c., extra-departmental	6,632	6,632
		2,723			
Chemicals and stores purchased in India	116				
Stationery (papers) from Stationery Office	468				
		584			
Shipping and landing charges and freight	267				
		267			
Balance to credit of Department		5,629			
Total		19,591	Total		19,591

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Statement showing the amount and value of work done for other Departments, &c., during the year 1889-90.

Departments, &c.	Photo-zincographic Printing.								Value.		Remarks.
	Sheets or sections or subjects.	Negatives.	Photo-transfer Prints.	Zinc Plates.	Silver Prints.	Blue Prints.	Pulls.	Copies.	£	s.	
Forest Department	154	348	674	65	1	510	3,760	5,506	5,379	2	(a) Already realised and paid into the Treasury.
Quarter Master General	14	30	52	14	...	...	4,128	3,964	951	1	
Miscellaneous	11	20	40	67	...	...	246	394	(a)302	6	
Total	179	398	766	146	1	510	7,624	9,864	6,632	9	

Statement of Departmental Work done during the year 1889-90.

Specification of Plate or Print.	Photo-zincographic Printing.											Remarks.
	Progress made.	Scale of maps.	Size of each sheet.	Sheets or subjects.	Negatives.	Photo-transfer prints.	Zinc plates.	Silver prints.	Blue prints.	Pulls.	Copies.	Value.	
		1 Inch=										*R a.*	
Assam Valley Series, Degree Sheets Nos. 13, 14-15, 16-17, 18-19, 20-21, 22-23, 24-25, 26, and 27-28	F	4 m.	½ D.E.	9	44	44	8	...	...	920	1,035	624 1	For Synoptical Volume.
Central Provinces Survey, Sheets Nos. 17 S.E./2, S.E./3, S.E./4; 18 N.E./1, S.E./1, N.E./2, S.E./2, S.W./2, N.E./3, S.E./3, N.E./4, N.W./4, S.E./4, S.W./4; 19 N.W./1, N.E./2, N.W./2, N.W./3, S.E./4; 20 N.W./3;													
25 S.W./1, and S.W./3	F & I	½ ,,	,,	19	115	103	17	...	...	2,550	2,550	1,733 2	
Chart (final) of South Konkan Coast Series	F	8 ,,	,,	3	9	18	1	...	...	360	360	195 14	For Synoptical Volume.
Chart (skeleton) of the principal chain of triangles west of the meridian of 92°	,,	...	½ ,,	1	1	4	1	...	...	124	516	44 8	For Professional Volume XII.
Chart of the Burma Coast Triangulation, season 1888-89. Nos. 61, 62 and 63	,,	2 ,,	,,	3	18	18	3	...	...	186	186	251 10	
Chart of Spirit-levelling operations	,,	16 ,,	¼ ,,	1	2	4	1	...	...	166	332	52 11	For Pamphlet, Spirit-levelled Heights, No. 5, Madras Presidency.
Clinometer, height indicator and contouring scale	* F	...	½ ,,	1	...	...	...	...	...	38	224	15 8	
Clock pillar plan, elevation and section	F	...	½ ,,	1	1	3	1	...	...	100	200	32 13	For Hand-book, Trigonometrical Branch.
Darjeeling Survey, portion of Daling hills, Sheets Nos. 1, 2, 3, 4, 5, 6, and 7	,,	½ ,,	,,	7	8	54	7	...	...	350	350	405 14	
Dehra Dun and Siwaliks Survey, Sheets Nos. 1, 2 and 3	* F	1 ,,	,,	3	...	...	...	...	...	149	149	36 10	
Do. do. do. do. XIV, XV, XXIII, XXIV and XXXIV	,,	½ ,,	,,	5	6	30	5	...	...	250	250	252 15	
Forms for Departmental use (Miscellaneous)	F & I	...	...	8	3	7	5	...	...	666	1,152	136 15	
Do. do. do. (Professional)	,,	...	...	62	22	214	42	...	...	15,670	17,618	3,235 3	
Gujarat Survey, Sheets Nos. 5, 26, 27, 28, 80 and 82	* F	1 ,,	D. E.	6	21	27	5	...	...	350	350	339 0	
Index to level charts	F	80 ,,	¼ ,,	1	1	4	1	...	...	119	476	40 5	For General Report.
Jaunsar and Bawar Survey Sheet	* F	1 ,,	⅛ ,,	1	...	8	1	...	...	35	35	50 14	
Kattywar Survey, Sheet No. 13 (2nd Edition)	,,	1 ,,	,,	1	...	...	...	...	...	50	50	10 12	
Level Chart No. 88 Bench-marks	,,	...	½ D. R.	1	1	3	1	...	...	25	75	27 9	
Level Sheet No. 66 (2nd Edition) bench-marks	,,	...	½ ,,	1	1	4	1	...	...	25	100	33 14	
Level in the Punjab, Sheet No. 66 (2nd Edition)	,,	2 ,,	D. E.	1	...	6	1	...	...	75	75	51 6	

Statement of Departmental Work done during the year 1889-90—continued.

Specification of Plate or Print.	Photo-zincographic Printing.											Remarks.
	Progress made.	Scale of maps.	Size of each sheet.	Sheets or subjects.	Negatives.	Photo-transfer prints.	Zinc plates.	Silver prints.	Blue prints.	Pulls.	Copies.	Value.
												R a.
Mirzapur Survey Sheet, Nos. 185, 185 N. E. and 200	F	1 inch= 1, & ½m.	D. E.	4	23	23	4	...	...	608	454	375 5	
North-East Trans-frontier Sheet No. 7 N. W.	*F	4 ,,	,,	1	....	...	....	...	...	31	31	14 6	
Plate I, Trigonometrical tower	F	...	½ ,,	1	1	4	1	...	...	43	172	36 11	For Hand-book, Trigonometrical Branch.
Do. II, Observatory Diagram	,,	...	½ ,,	1	1	4	1	...	...	43	172	36 11	
Do. III, Signal lamp	,,	...	½ ,,	1	1	4	1	...	...	44	176	31 0	
Do. of the Cutch Coast Series (I and II)	,,	12 m.	½ ,,	2	2	8	2	...	...	266	1,064	92 6	
Do. do. Guzerat Longitudinal Series	,,	12 ,,	½ ,,	1	1	4	1	...	...	133	532	46 3	For Professional Volume XIV.
Do. do. Kattywar Meridional Series (I)	,,	12 ,,	½ ,,	1	1	4	1	...	...	133	532	46 3	
Do. do. Singi Meridional Series	,,	12 ,,	½ ,,	1	1	4	1	...	...	133	532	46 3	
Do. do. South East Coast Series (I and II)	,,	12 ,,	½ ,,	2	2	8	2	...	...	266	1,064	68 15	For Professional Volume XIII.
Do. do. do. do. Ceylon Branch (III)	,,	12 ,,	½ ,,	1	1	4	1	...	...	133	532	59 4	
Routes in South-West Persia (Colonel (Gerard's)	,,	8 ,,	½ ,,	7	12	...	...	12	12	...	2 sets.	99 0	
Reduction chart of Southern Trigon in two parts	,,	32 ,,	,,	2	13	66	8	...	...	2,030	1,015	692 7	For Professional Volumes XII & XIII.
Sketch map of the course of Sangpo River (revised)	,,	12 ,,	¼ ,,	1	5	10	2	...	...	460	460	122 5	For General Report.
Table of distances in links corresponding to 20-foot Subtense	*F	...	½ ,,	6	...	...	...	...	...	104	104	11 3	
Other maps for office use, Surveyor-General's office, &c.	F & I	...	...	80	262	245	52	...	...	3,672	2,260	3,273 5	
Copies of Maps of other Departments taken for Departmental use, 1889-90.													
Calculation of acres by planimeter	F	...	½ D. E.	1	4	4	1	...	...	10	10	2 14	
Forest Survey in Berar, Sheets Nos. 12 S. E./1, S. E./2, S. E./3, S. E./4; 19 Kharimal and Chaora Kund; 19 Raipur; 19 N. E., S. E., N. E./1, N. E./2, N. W./3, N. W./4, S. W./1, S. W./3, S. W./4; 20 N. W., N. W./1 and N. W./2.	,,	¼ & ¼ m.	½ & ½ D. E.	19	6	44	7	...	480	270	285	114 12	Copies retained for office record, of maps &c., requisitioned for by other departments, the cost of press pulls and stationery being all that is here charged to the Survey Department; the numbers in columns 5 to 8 therefore stand excluded from the totals.
Forest Survey in Chota Nagpore (Bengal), Sheets Nos. 127 S. E./1, S. E./4, S. W./2; 156 S. W./3; 157 N. W./1 and 158 S. W./3	,,	½ ,,	,,	6	...	...	6	...	...	90	90	38 4	
Forest Survey in Kheri, Sheets Nos. 113 N. W., S. E., S. W.; 114 S. E. and N. E.	,,	½ ,,	,,	5	...	...	5	...	...	75	75	31 14	

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

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TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

SOLAR PHOTOGRAPHIC SECTION.—This section has no real connection with the work of this office; but was established at Dehra as a matter of convenience, so that it might be under suitable supervision without expense to Government. It had its origin as follows:—

In June 1877 Mr. Norman Lockyer submitted a memorandum to the Secretary of State for India in which he advocated the taking of Solar Photographs in India for the sake of the study of the sun; as the climate was such that a more complete series would probably be obtained there than at any other place where such observations were in progress. The Secretary of State was pleased to accept the suggestion and sanctioned the engagement of a Sapper, on R250 per mensem, who had been trained by Mr. Lockyer himself; and, in his despatch to the Governor-General of India in Council, he adds that it would probably be best to place him under the orders of the Superintendent of the Trigonometrical Survey. It thus came about that the Sapper was located at Dehra, the head-quarters of the Superintendent of the Survey, where there was an observatory which could be placed at his disposal and where there would be an officer capable of supervising the work. All expenses were, however, to be debited to "Industry, Science and Art."

Work was commenced at Dehra in May 1878, but was interrupted for some months in 1879 by the sudden death of the photographer and the difficulty of supplying his place. Another man was eventually trained for the work, and since then there has been no interruption in the series of negatives, except such as is due to bad weather. The diameter of the sun's image was at first only 4 inches, but by changing the enlarging lens of the photo-heliograph, pictures were obtained 8 inches in diameter. Subsequently another instrument was received from England which gives 12-inch pictures. Both instruments are now worked, the small for daily pictures and the large when any special features are visible on the sun's disc.

During the eclipse of 17th June 1890, some 8-inch and 12-inch negatives were taken and sent to England with the daily negatives.

Statement of expenditure (Dr.) and amounts credited (Cr.) during the year 1889-90.

Dr.			Cr.		
	R	R		R	R
Superintendence	600		Value of negatives and silver prints taken for the Solar Physics Committee, under authority from the Secretary of State for India (debitable to the Industry, Science and Art Departments)	3,465	3,465
Solar Photographer	1,200				
Establishment	204				
Contingencies	839				
		2,903			
Chemicals and stores received from England	498				
		498			
Chemicals and stores purchased in India	15				
		15			
Shipping and landing charges and freight	49				
		49			
TOTAL	...	3,465	TOTAL	...	3,465

Table of Working Facts for the year 1889-90.

1889-90.	Number of days.				Number of Negatives.								Number of working days when Solar Phenomena were	
		Failures.			Solar Phenomena.						Total.			
	When negatives were taken.	From bad weather.	From various causes.	Total.	Spots and Faculæ.		Spots only.		Faculæ only.		None.			
					8″	12″	8″	12″	8″	12″	8″	12″	8″	12″	Visible.	Absent.
October	31	...	...	31	8	...	8	...	34	...	7	...	57	...	27	4
November	30	...	...	30	4	...	...	...	36	...	16	...	56	...	21	9
December	29	2	...	31	25	5	2	...	9	...	45	...	51	5	20	9
January	27	4	...	31	15	...	9	...	19	...	4	...	47	...	24	3
February	26	2	...	28	...	...	2	...	30	...	13	...	45	...	18	8
March	27	4	...	31	18	4	...	...	15	...	12	...	45	4	19	8
April	25	...	...	30	6	...	4	...	18	...	16	...	44	...	15	10
May	31	...	...	31	18	2	2	...	22	...	11	...	53	2	25	6
June	28	2	...	30	9	...	2	...	26	...	11	...	48	...	22	6
July	23	8	...	31	13	...	3	...	10	...	5	...	31	...	19	4
August	19	12	...	31	10	...	2	...	12	...	6	...	30	...	15	4
September	24	6	...	30	38	...	...	...	2	...	1	...	41	...	23	1
TOTAL	320	45	...	365	164	11	34	...	233	...	117	...	548	11	248	72

Five hundred and ninety-nine silver prints of the 8-inch and eleven of the 12-inch pictures were prepared, and weekly despatches of both silver prints and negatives made as usual to the India Office.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Table contrasting Visibility of Sun at Dehra Dun and Greenwich.

Year.	At Dehra Dun. Number of days on which negatives were taken.	Percentage of days on which negatives showed features.	Number of days when sun was invisible.	At Greenwich. Year.	Number of days on which negatives were taken.	Remarks.
1880-81*	307	96	55	1880	156	* From 1st October to 30th September following.
1881-82	328	100	37	1881	181	
1882-83	318	100	47	1882	221	
1883-84	285	100	78	1883	215	
1884-85	284	100	81	1884	154	
1885-86	290	100	75	1885	206	
1886-87	302	98	61	1886	199	
1887-88	328	91	38	1887	188	
1888-89	315	71	50	1887-88†	205	† Year ending 10th May 1888. Obtained from Report to the Board of Visitors.
1889-90	320	78	45	1888-89	Not obtainable.	
Means	308	...	57	...	192	

DRAWING SECTION.—The details of the work done in this section are given in the tables which follow:—

Statement of expenditure (Dr.) and amounts credited (Cr.) during the year 1889-90.

Dr.	₹	₹	Cr.	₹ a.	₹
Superintendence	3,383		Departmental maps, charts, &c.	21,795 11	
Establishment	19,229		Maps, &c., Extra-Departmental	950 5	
Contingencies and travelling allowances	50				
Stationery from Stationery Office	84				22,746
		22,746			
Total	...	22,746	Total	...	22,746

Statement showing the value of work done for other Departments, &c., during the year 1889-90.

Departments, &c.	Value. ₹ a.
Quarter Master General's Department	19 11
Foreign Department	570 12
War Office, Intelligence Division, London	131 3
Forest Survey Office	67 0
Director, Forest School	80 12
Director, Geological Survey	45 2
Deputy Conservator of Forests, Darjeeling	32 13
Deputy Commissioner, Simla	3 0
Total	950 5

Statement showing work performed during the year 1889-90.

Title of Map.	Number of Sheets.	Scale. In. M.	Remarks.
General Maps.			
Revised map of Tibet by Mr. A. W. Paul C. S.	1	1 = 16	Additions and corrections made and final press order given.
Standard Maps.			
North-West Provinces Survey. Sheet No. 185, District Mirzapur	1	1 = 1	For reduction to half scale. Completed and final press order given.
Kumaun and Garhwál Survey. Sheet No. 17	1	1 = 1	Corrected, in hand.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Statement showing work performed during the year 1889-90—continued.

Title of Map.	Number of Sheets.	Scale.	Remarks.
		In. M.	
Standard Maps—continued.			
Gujarat Survey.			
Sheets Nos. 6, 29 and 30 . .	3	1 = 1	For reduction to half scale. Corrections made for reprints.
Central India and Rajputana Topographical Survey.			
Sheet No. 260 (2nd Edition) .	1	1 = 1	In hand.
North-Western Trans-Frontier Series.			
2 Maps	2	1 = 4	Final press order given.
4 Maps	4	1 = 8	Ditto ditto.
8 Maps	8	1 = 8	Transferred to Simla Drawing Section.
2 Maps	2	1 = 8	Corrections made.
Northern Trans-Frontier Series.			
1 Map	1	1 = 4	Transferred to Simla Drawing Section.
South-Western Asia Series.			
2 Maps	2	1 = 8	Final press order given.
5 Maps	5	1 = 8	Transferred to Simla Drawing Section.
Index Maps.			
Map of India showing topographical triangulation executed by Great Trigonometrical Survey . .	1	1 = 96	For Surveyor-General's office.
Skeleton chart of principal chains of triangles west of the meridian of 92° .	1	1 = 128	Prepared on 1″=96 miles scale for reduction, for Professional Volumes. Final press order given.
Spirit-levelling operations in the Madras Presidency	1	1 = 16	Drawn on double the scale for reduction to one-half for pamphlet No. 5, Madras Presidency. Final press order given.
For Annual Administration Report .	4	Various.	Corrected to date and sent to press.
Miscellaneous Maps, &c.			
Revised map of the course of the Sangpo	1	1 = 12	Prepared on $\frac{1}{8}$-inch scale for reduction. Corrected for Annual Report, 1888-89. Final orders given.
Diagrams of figures of the Great Trigonometrical Series.			
Ceylon Branch Series of the South-East Coast	1	1 = 12	Prepared on $\frac{1}{4}$-inch scale for reduction to one-third, for Professional Volumes. Final press order given.
Forms—Professional	4	...	Prepared and final press order given.
Charts.			
Triangulation, Assam Longitudinal Series	4	1 = 8	Prepared for Surveyors proceeding to Lushai Expedition.
Triangulation, South Konkan Coast Series	2	1 = 4	For reduction to one-half scale for Synoptical Volumes. Final press order given.
Triangulation, Assam Valley Series, Degree Sheets Nos. 13, 14-15, 16-17, 18-19, 20-21, 22-23, 24-25, 26 and 27-28	9	1 = 4	For Synoptical Volumes. Final press order given.
Triangulation, Mangalore Meridional Series	2	1 = 4	For reduction to one-half scale for Synoptical Volumes. In hand.
Triangulation, South-East Coast Series .	2	1 = 4	Ditto ditto.
Triangulation, Madras Meridional and Coast Series	2	1 = 4	Ditto ditto.
Triangulation, Great Arc Meridional Series, Section 8° to 18° . .	4	1 = 4	Ditto ditto.
Triangulation, Madras Longitudinal Series	1	1 = 4	Ditto ditto.
Triangulation, Singi Meridional Series .	2	1 = 4	Rough charts, prepared for use of the Computing Office.
Triangulation, Khánpisura Meridional Series	2	1 = 4	Ditto ditto.
Captain Garling's Triangulation of Sugar Survey	1	1 = 8	Ditto ditto.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Statement showing work performed during the year 1889-90—concluded.

Title of Map.	Number of Sheets.	Scale.	Remarks.
Charts—continued.		In. M.	
Reduction of Southern Trigon	2	1 = 12	For reduction to one-half scale for Professional Volumes. Final press order given.
Reduction of South-West Quadrilateral	1	1 = 12	For reduction to one-half scale for Professional Volumes. In hand.
Level Sheet No. 67—Parts of Umballa, Ludhiána and Patiála, &c.	1	1 = 2	In hand.
Level Sheet No. 74—Parts of Patiála, Nábha, Jánd, &c.	1	1 = 2	Ditto.
Level Sheet No. 88—Parts of Baháwalpur and Montgomery	1	1 = 2	Ditto.
Level Sheet No. 89—Parts of Montgomery and Lahore	1	1 = 2	Ditto.
Trace of Level data in Montgomery district	1	1 = 2	For office use in compilation of Level Charts.
Trace of Level data of Indian Midland Railway	7	1 = 1	Ditto ditto.
Diagrams of Bench-marks for Level Sheet No. 88	1	...	Prepared and final press order given.
Maps coloured	2,749	...	

Maps examined.	Number of Sheets.
General maps	3
Original Standard maps	37
Trans-Frontier maps	9
Index maps	5
Miscellaneous maps	12
Tracings of original maps	2
Photographic proofs of standard sheets and various other maps	191
TOTAL	259

N. B.—In addition to the above, many miscellaneous jobs have been performed, such as assisting in Photographic Office, completing Forest Survey original maps in respect to headings, foot-notes, &c., for press, supplying Afghan Boundary Commission, synopsis of triangulation to Simla Drawing section, transferring confidential records to Simla Drawing section and to Calcutta Office; translating Report of Routes surveyed by Ahmed Ali Khan, sub surveyor, Kashmir Frontier.

Statement of work done for other Departments, &c., during the year 1889-90.

Title of Map.	Number of Sheets.	Scale.	Remarks.
General Maps.		In. M.	
Map of Persia	6	1 = 16	Revised and corrected for the War Office, Intelligence Division, London.
Tracing of routes	1	1 = 8	Prepared for Lieutenant Vaughan.
Exploration map	1	1 = 16	For the Foreign Department.
Administrative Report Map.			
Geological map of Naini Tal	1	4 = 1	Prepared for Director, Geological Survey. In press.
Standard Maps.			
Forest Surveys	35	Various.	Completed headings and foot-notes, references, &c., and final press order given for Forest Survey Branch.
Miscellaneous.			
Diagrams of geometrical construction, &c.	10	...	Completed for Forest School and final press order given.
Forest boundary along Teesta	1	4 = 1	Plotted for Deputy Conservator of Forests, Darjeeling.
Tracings of boundary between Kumhársain, Ghind and Theog	1	1 = 2	Prepared for Deputy Commissioner, Simla.
Maps coloured	7,701	Various.	

G. I. C. P. O.—No. 16 S. G.—22-4-91.—450.

1891.

FILE NO. 19.

GOVERNMENT OF INDIA.

SERIAL NO. 11.

REVENUE AND AGRICULTURAL DEPARTMENT.

SURVEYS.

RESOLUTION.

No. $\frac{1951\text{-}1963}{19}$.

Dated Simla, the 25th August 1891.

SUBJECT.

General Report on the Operations of the Survey of India Department, for the year 1889-90.

[J. S N.]

G. C. Press, Simla.—No. 359 R. & A. D.—28-8-91.—720.

Extract from the Proceedings of the Government of India, Revenue and Agricultural Department, No. $\frac{1051-1062}{19}$ *(Surveys), dated Simla, the 25th August 1891.*

READ—

The General Report on the operations of the Survey of India Department, for the year 1889-90.

RESOLUTION.

The report, which, as usual, is divided into three parts, opens with a summary of the operations of the several field parties and of the work of the head-quarters offices, the detailed accounts of which occupy Parts II and III respectively. The appendix contains some interesting extracts from narrative reports of executive officers.

Out of a total number of 24 parties and 4 detachments, working during the year, 4 parties continued to be engaged on scientific surveys connected with the principal triangulations, on astronomical observations for fixing latitudes and longitudes, and lastly on tidal and spirit-levelling operations. Of the remainder, 4 parties were employed on topographical, 4 on forest, 3 on traverse, and 7 parties and one detachment on cadastral surveys; while two parties and 3 detachments carried out geographical surveys and reconnaissances.

2. Principal triangulation for Upper Burma was continued on the meridian of 96°30′, and a portion of the trigonometrical party proceeded with the scheme of triangulating the coasts of India and Burma with a view to furnish artificial beacons as well as natural land-marks as a basis for future operations of the Marine Survey Department. Thirty-five points were fixed off the coast of Chittagong, extending to Akyab in Burma.

The electro-telegraphic longitude operations were resumed, and seven arcs of longitude were measured between trigonometrical stations in the Punjab, Baluchistan and Central India.

3. Observations with the self-registering tide-gauge were taken at 17 stations in India, Burma, Ceylon and the Andaman Islands. In the place of three old observatories dismantled at Colombo, Galle and Madras, arrangements were made for establishing new observatories at Trincomallee, Minicoy and Diamond Island. It has also been decided to extend the tidal observations to the Persian Gulf.

4. Topographical surveys were continued in Bombay, Baluchistan and the Himalayas, and a new party took up the survey of the tin-bearing tracts in the Mergui district of Burma. The importance of developing the tin-mining industry justified the diversion of this party from revenue to topographical work.

In addition to the work of regular topographical parties, small areas intervening between those surveyed for revenue purposes were topographically surveyed by cadastral and forest survey parties in order to obtain complete topographical maps. The areas topographically surveyed amount to 13,652 square miles. The traverse party employed in the plains of the Punjab tested and mapped 1,766 square miles in the Ferozepore district. These maps are compiled on an accurate traverse basis, the topography being obtained by

reduction from village maps prepared by the Settlement Department, which are subsequently tested in the field.

5. Forest Surveys constituted the regular work of four parties employed respectively in the Central Provinces, Bombay, Madras and Lower Burma, and were also effected in Jhansi and Kumaun by detachments of the cadastral party working in the North-Western Provinces.

The aggregate area surveyed in all four Provinces was 1,646 square miles, being 9 square miles less than that of the preceding year. This decrease is due to the small outturn in Burma, where the early commencement of the rainy season prostrated many of the surveyors with malarious fever and prevented progress in the field work.

6. Of the seven parties and a detachment employed on cadastral surveys, three parties and the detachment were employed in Bengal, two parties in Burma, one in the North-Western Provinces and one in Assam. The outturn of aggregate area surveyed, *viz.* 4,781 square miles, though less than that of the preceding year by 55 square miles, was on the whole satisfactory, considering the embarrassments with which some parties had to contend owing to the difficult nature of the country in which they were employed, as well as to its unhealthiness which rendered desertions among menials, and even of surveyors, not uncommon. In Lower Burma, the natives of the country were largely employed, but on an average they were found to turn out only $\frac{3}{7}$ths of the work that could be done by Hindustani amins. In view of the heavy cost of conveying the latter to Burma, it is of special importance to encourage the employment of local agency in that Province, and the Government of India are glad to observe that every effort is being made to train the Burmans in survey work.

The second Burma party was reorganized for cadastral work, having previously been engaged on traverse surveys in the Central Provinces, and was employed in the Kyaukse district. The network of small canals, regarding which particulars are given at page xlvii of the appendix, is said to be the most remarkable feature of the district and its chief source of wealth; but inundations were a great hindrance to locomotion and retarded survey work. Mr. Scott, the officer in charge of the party, succeeded, however, in completing the survey of the district notwithstanding these difficulties.

Great credit is due to Colonel Sandeman for effecting a cheap survey in the Jhansi district of the North-Western Provinces. This was executed entirely through the agency of patwaris trained as village surveyors; the cost rate per square mile being only Rs. 54 for the complete operations of traverses, field survey and record-of-rights. The same system was attempted, but failed, in the Garhwal district owing to the absence of suitable village establishments and other causes, but the system was introduced with more success in the Rampur State. Cadastral surveys were also completed, almost entirely by the patwaris, in the Sub-Himalayan tracts of the Garhwal Bhabar, Kumaun Bhabar, and in the Terai district. The cost of field surveys by local agency in the Kujang and Kanika estates in Orissa was Rs. 16 per square mile, besides Rs. 30 to 40 per square mile for chainmen. The same party started the survey of Pooree and Cuttack, while another commenced operations in Backergunge, and a detachment surveyed a portion of the Burdwan estate.

In Assam, the survey of the Sibsagar and Nowgong districts was commenced. Traverse surveys progressed satisfactorily in the Punjab and the Central Provinces, but in Burma where work of this nature was slow owing to the extremely difficult nature of the country, only 923 square miles were surveyed. This however was the first year's work, the party having been transferred to Burma after completing traverse surveys in the Central Provinces.

7. The Government of India have during the year found it necessary to draw the attention of the Surveyor General to the necessity of the officials responsible for the administration of Revenue Surveys maintaining a constant personal communication with Provincial authorities. Under the system of decentralization which now prevails, the Local Governments have become more responsible than was previously the case for the economical execution of revenue surveys, and for the utilization, as far as possible, of Provincial establishments—on the principles laid down in the Survey Resolution of 1882, which, while requiring for topographical purposes that all cadastral maps should be based on an outline or skeleton map professionally prepared, demand that the utmost use should be made of local agency. An intimate relation between the Survey Department and Provincial authorities has thus been established, which necessitates for its successful maintenance continual personal communication between the responsible officers of the revenue branch of the Department and the local officials. Tours of inspection, however much required under previously existing circumstances, have therefore become more imperatively needed, in order to prevent the occurrence of delays, misunderstandings, and the natural friction which must otherwise result from the combined working of separate establishments. The report under review does not indicate with sufficient clearness the tours made with this object by the Surveyor General or the Deputy Surveyor General specially responsible for the superintendence of revenue surveys. The Government of India have desired, therefore, that in future reports the visits of the responsible officers of the Department to each Province should be described in more complete detail, and the nature of any difficulties which have occurred and the means taken to overcome them more fully set forth.

8. The total areas geographically surveyed in countries on the north-east and north-west borders of India, amount to 97,792 square miles. Regular surveys were undertaken in seven districts of Upper Burma by two parties, while detached sections accompanied military and exploring expeditions (1) against the Kachin tribes, south of Bhamo and to the Momeit State; (2) to the Shan States of Northern Theinni Thibaw and Taungbaing; (3) to the States of Baw, Yatzauk, &c., and (4) to the Chinbók hills.

Another detachment accompanied the Burma-Siam Boundary Commission, while two detachments went into the Chin Lushai Hills with military expeditionary forces.

A large addition was made to the geographical survey of Baluchistan; and expeditionary parties surveyed parts of the Zhob Valley, Western Mekran and the Perso-Baluch frontier. An Assistant Surveyor who was deputed to Persia, in association with the Intelligence Branch of the Quartermaster General's Department, reconnoitred about 25,000 square miles.

9. The work of the Head-quarters Offices continues to be satisfactory. 166,604 maps, valued at Rs. 1,22,472, were issued during the year, and there was a very large increase in the work of the Photographic and Lithographic Offices. The new steam machinery for printing was set up, though the zinc printing machine could not be worked till late in the year under report. It helped, however, to increase the outturn of work very largely. Mathematical instruments, valued at Rs. 2,70,458, were issued on indent, being Rs. 45,000 more in value than in the preceding year.

10. It remains to notice the work of the Dehra Office, which comprises chiefly the final reduction and publication of operations of the Great Trigonometrical Survey. In this connection, it is observed that the chart accompanying the report does not show clearly what portion of the triangulation exhibited on it relates to the field work of the year under report. The tabular statement on page xc of the appendix shows that the value of computations was Rs. 10,015, and the total value of the work of the computing section was Rs. 41,644, as compared with Rs. 15,521 and Rs. 44,604 respectively in the year 1888-89 (page xciv of appendix in the report of that year). These figures require explanation in view of the fact that the computing section was strengthened by the employment of ten extra computers. The Government of India desire that a separate report on the progress of the work may be furnished, and trust that in any case the work of the Dehra Office will be completed by the end of the year 1893-94 as contemplated.

11. The Survey Department has continued to suffer from the heavy strain thrown on an undermanned service by the demand for new surveys in Upper Burma. The recruitment of the Department was to some extent contracted under the orders of the Government of India in view of the desirability of avoiding any sudden diminution of the survey programme which might be entailed by the Department being maintained for any protracted period at its full strength, as well as of the contingency now imminent of having to find employment for the surplus officers of the Survey Departments of the Madras and Bombay Presidencies in which the Revenue Surveys are drawing to a close. But the remunerative results which are anticipated from the rapid completion of the Revenue Surveys in Burma, and the renewed probability of the survey of Behar have led to a recent decision that the parties now working should at present be maintained at their full strength. The thanks of the Government of India are due to the Surveyor General and the officers of his Department for having during the past year produced such satisfactory results as are shown in the report under review, notwithstanding the difficulties caused by casualties and deficient recruitment.

ORDER.—Ordered that the foregoing Resolution be forwarded to the Surveyor General of India, to the Local Governments and Administrations noted on the margin,* and to the Foreign, Military, and Public Works Departments

Ordered also that the Resolution be published in the Supplement to the *Gazette of India*.

* Madras. Bombay. Bengal. North-Western Provinces and Oudh. Punjab. Central Provinces. Burma. Assam. Coorg.

[True extract.]

E. C. BUCK,

Secretary to the Government of India.

Photo-etching.

Survey of India Offices, Calcutta, February 1882.

SIMVO - 22,300 Ft. (EASTERN SPUR OF KINCHINJUNGA - SIKKIM HIMALAYAS) FROM THE NORTH-WEST.

From a Photograph by Messrs. Johnston & Hoffmann.

GENERAL REPORT

ON THE

OPERATIONS

OF THE

Survey of India Department

ADMINISTERED UNDER

THE GOVERNMENT OF INDIA

DURING

1890-91.

PREPARED UNDER THE DIRECTION OF
COLONEL H. R. THUILLIER, R.E.,
SURVEYOR-GENERAL OF INDIA.

CALCUTTA:
OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.
1892.

CALCUTTA:
GOVERNMENT OF INDIA CENTRAL PRINTING OFFICE,
8, HASTINGS STREET.

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INDIA

SHEWING THE PROGRESS OF THE IMPERIAL SURVEYS

To 1st October 1891.

Scale 1 Inch=120 Miles or 1 inch to

REFERENCE.

TOPOGRAPHICAL SURVEYS,
Mostly on Scales of 1 Inch = 1 Mile
Completed
In progress

REVENUE SURVEYS,
On 4 Inch and larger Scales
Completed
In progress

Geographical Reconnaissance on various scales

Railways opened

Do. not opened

Roads, Bigh

Do. Minor

The numerals denote the height in feet above sea level.

Published under the direction of Colonel H. H. Thuillier, R.E., Surveyor-General of India, April 1892.

Litho., S. I. O., Calcutta.

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TO THE
GREAT TRIGONOMETRICAL SURVEY
OF
INDIA
BAY OF BENGAL
CEYLON

GENERAL REPORT

ON THE

Operations of the Survey of India

DURING THE SURVEY YEAR

1890-91.

PART I.

SUMMARY.

1. The operations of the Department that are now reported on are for the survey year ending 30th September 1891.

2. The general administration of the Department and the superintendence of the Topographical Branch have continued in the hands of Colonel H. R. Thuillier, R.E., throughout the year. The direct supervision of the Revenue Branch has been carried on by Lieutenant-Colonel C. Strahan, R.E., and that of the Trigonometrical Branch by Colonel G. Strahan, R.E., except for three months, while he was absent on privilege leave, when Mr. W. H. Cole, M.A., officiated in the post.

3. As regards the Cartographic and other offices at the Head-Quarters, Colonel W. H. Wilkins, S.C., has remained in charge of the Drawing and Engraving Offices throughout the year, and the Correspondence and Mathematical Instrument Offices continued under the superintendence of Colonel M. W. Rogers, R.E. On the departure on furlough of Colonel J. Waterhouse, S.C., in May 1891, Mr. T. A. Pope was appointed to officiate in the charge of the Photographic and Lithographic Office, and retained the post during the remainder of the year.

4. Field operations have been carried on during the year under review by 23 parties and seven small detachments. Of these one party was employed on trigonometrical surveys, four parties and a detachment on topographical surveys, four parties on forest surveys, seven parties and one detachment on cadastral surveys, two parties on traverse surveys, three parties on scientific operations, and two parties and five small detachments on geographical surveys. The following tabular statement shows collectively the whole of these operations, and it is grouped according to the scope and nature of the work on which the parties were severally employed:—

Statement of Survey Operations and Parties.

Number of Party.	Nature and *locale* of operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
	Trigonometrical Survey.				
24	Burma	13	Lieutenant C. F. Close, R.E.	.....	D. S. G., Trig.
	Topographical Surveys.				
10	Bombay . . .	14	Colonel H. S. Hutchinson, S.C. Lieutenant-Colonel J. Hill, R.E.	2″ = 1 mile for reduction to half scale; 1″ = mile and ½″ = 1 mile for reproduction.	Ditto, Rev.
13	Mergui . . .	16	Mr. A. D'Souza . . .	1″ = 1 mile for reproduction.	Ditto, ditto.

Statement of Survey Operations and Parties.

Number of party.	Nature and *locale* of operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
15	Baluchistan	19	Lieutenant-Colonel T. H. Holdich, R.E. Captain R. J. Mackenzie, R.E.	2″ = 1 mile, ½″ = 1 mile, and ¼″ = 1 mile for reproduction.	D. S. G., Topo.
18	Himalayas	21	Major St. G. C. Gore, R.E.	4″ = 1 mile for reproduction and reduction to half scale; 2″ = 1 mile and 1″ = 1 mile for reproduction.	Ditto, Trig.
Det.	Indus river-ain	22	Mr. J. S. Pemberton	4″ = 1 mile for reproduction.	Ditto, Rev.
	Forest Surveys.				
14	Central Provinces	24	Colonel J. R. Wilmer, S.C.	4″ = 1 mile for reproduction.	Ditto, Trig.
17	Bombay	26	Colonel A. Pullan, S.C. Mr. A. M. Lawson. Colonel H. S. Hutchinson, S.C.	16″ = 1 mile, 8″ = 1 mile, and 4″ = 1 mile for reproduction.	Ditto, Topo.
19	Madras	27	Lieutenant-Colonel J. R. McCullagh, R.E.	4″ = 1 mile for reproduction.	Ditto, ditto.
20	Lower Burma	30	Colonel R. Beavan, S.C.	4″ = 1 mile and 2″ = 1 mile for reproduction.	Ditto, ditto.
	Cadastral Surveys.				
2	Eastern Bengal	31	Mr. F. Grant	16″ = 1 mile for reproduction; 2″ = 1 mile for reduction to half scale.	Ditto, Rev.
3	Upper Burma	35	Mr. G. B. Scott Mr. B. G. Gilbert-Cooper.	16″ = 1 mile for reproduction.	Ditto, ditto.
4	Western Dooars	37	Captain G. B. Hodgson, S.C.	16″ = 1 mile and 4″ = 1 mile for reduction to half scale.	Ditto, ditto.
5	North-West Provinces	43	Lieutenant-Colonel J. E. Sandeman, S.C.	16″ = 1 mile and 4″ = 1 mile for reproduction.	Ditto, ditto.
6	Assam	48	Mr. E. C. Barrett	16″ = 1 mile for reproduction.	Ditto, ditto.
7	Lower Burma	50	Mr. C. Wood	16″ = 1 mile and 4″ = 1 mile for reproduction.	Ditto, ditto.
8	Orissa ,,	54	Mr. W. H. Patterson	16″ = 1 mile for reproduction.	Ditto, ditto.
Det.	Burdwan Khas Mahals	57	Mr. T. Shaw	Ditto ditto.	Ditto, ditto.
	Traverse Surveys.				
9	Central Provinces	60	Mr. G. H. Cooke	16″ = 1 mile (skeleton plots).	Ditto, ditto.
12	Lower Burma	61	Mr. E. J. Jackson	Ditto ditto.	Ditto, ditto.
	Geodetic.				
22 & 23	Madras Presidency	63	Lieutenant G. P. Lenox-Conyngham, R.E.	.....	Ditto, Trig.
	Tidal and Levelling Operations.				
25	India	65	Lieutenant-Colonel J. Hill, R.E.	.....	Ditto, ditto.
	Geographical Surveys.				
11	Upper Burma	67	Mr. M. J. Ogle	¼″ = 1 mile	Ditto, Topo.
21	Upper Burma	68	Captain F. B. Longe, R.E.	Ditto	Ditto, ditto.
Det.	Miranzai border	71	Captain R. A. Wahab, R.E. Captain R. J. Mackenzie, R.E.	1″ = 1 mile and ½″ = 1 mile.	Ditto, ditto.
,,	Black Mountain country	72	Captain R. A. Wahab, R.E.	2″ = 1 mile and ½″ = 1 mile.	Ditto, ditto.
,,	Upper Irrawaddy	74	Major J. R. Hobday, S.C.	Ditto	Ditto, ditto.
,,	Eastern Frontier, Shan States.	76	Captain T. F. B. Renny-Tailyour, R.E.	Ditto	Ditto, ditto.
,,	Kyaington-Chiengmai Frontier.	77	Mr. J. M. Kennedy	Ditto	Ditto, ditto.

The total area that has been surveyed in detail during the year amounts to 1,17,915 square miles. In addition to this, the traverse operations carried on for the purpose of furnishing a basis for field surveys under Settlement Departments comprise an area of 4,593 square miles. The following is a summary of the operations of the different field parties in the order in which they appear in the above statement. A detailed report of the work of each party for the year under review will be found in Part II.

TRIGONOMETRICAL SURVEYS.

5. The chief operations have been confined, as in the previous year, to the extension of the principal triangulation for Upper Burma, on the meridian of 96° 30′. One party only was employed on this work and succeeded in extending the series northwards for a distance of 44 miles, covering an area of 900 square miles. An easier description of country has now been entered upon, and the progress may be expected to be somewhat more rapid in future.

6. The observations at the four stations required to complete the series of secondary triangles, along the parallel of 30° N. latitude from the Great Indus series to the Khwaja Amran range beyond Quetta, were executed during the year in connection with the work of the Baluchistan survey. The season's work embraces an area of 960 square miles.

TOPOGRAPHICAL SURVEYS.

7. Four parties and one detachment have been employed on this class of operations during the year. Of these, the four parties have carried on, as before, topographical surveys on various scales in the Bombay Presidency, in Burma, in the tin-producing tracts of Mergui, in Baluchistan, and in the Himalayas. The detachment was employed on special work in the Punjab for the Local Government; its operations comprised a *mauzawar* survey on the 4-inch scale of that portion of the river Indus lying between district Dera Ghazi Khan and the Bahawalpur State, with a view to the laying down of a fixed line of boundary between the district and State.

8. In addition to the work of the regular topographical parties, several small areas have been topographically surveyed by other parties in connection with cadastral and forest operations. These small areas generally consist of intervening tracts not required for revenue purposes, and they are surveyed in order to complete the topography of the standard maps in which the revenue areas fall.

9. The areas topographically surveyed on various scales during the year amount to a total of 10,193 square miles compared with 13,652 in the previous year. The decrease is principally due to the smaller out-turn of regular topography by the Baluchistan party, consequent on the many calls on that party to provide surveyors to accompany the various military expeditions which took place on the North-West Frontier.

The total area is made up as follows:—

3,044	square miles	surveyed	on	the	½-inch	scale.
2,358	,,	,,	,,	1	,,	,,
3,747	,,	,,	,,	2	,,	,,
1,044	,,	,,	,,	4	,,	,,

FOREST SURVEYS.

10. Under this head the four parties employed during the previous year in the Central Provinces, the Bombay and Madras Presidencies, and in Lower Burma, have continued their previous operations. In addition to their work, forest surveys have been carried on in Bengal and in the North-West Provinces by detachments from the cadastral survey parties employed there.

11. In the Central Provinces, one party has continued the survey of the first and second class forest reserves in districts Hoshangabad and Betul, carrying on at the same time the classification of forest growths and soils therein. The operations again lay in a tract of country which is notoriously unhealthy,

and the field work had consequently to be restricted to a period of four months only; the out-turn slightly exceeds that of the previous year.

12. In Bombay, the operations were in continuation of those carried on during the previous year, *viz.*, surveys on the 8-inch scale of the forests in North Kanara, Dharwar, Poona, and South Thana districts and on the 4-inch scale in Poona and Ahmednagar districts. In addition, a small area was surveyed on the 16-inch scale in the Poona district. The out-turn of this party is again satisfactory, and exceeds that of last year by 27 square miles.

13. In Madras, forest survey operations were continued in the Madura and Tinnevelly districts, and the out-turn of work obtained is very satisfactory, the total area surveyed during the season amounting to more than that of the previous two seasons put together. The physical and climatic difficulties were as great as those previously met with, and the improvement is due to the experience gained by the newly trained agency which had to be organized when the work was first started. It is satisfactory, also, to note the decrease in the cost rate of the survey, which has fallen from R162 per square mile in the first year of these operations, 1888-89, to R112 in the year under report.

14. In Lower Burma, the survey of the reserved forests in districts Prome and Toungoo has been continued on the 4-inch scale and the intervening tracts on the 2-inch scale. The out-turn of topography of this party more than doubles that of the previous year, which however, for reasons given in last year's report, was unusually small. The difficulties of the country under survey are exceptionally great, and the result of the season's operations is satisfactory.'

15. In connection with the cadastral surveys, an area of 174 square miles of forest reserves was surveyed in the Western Dooars, in which the forest growths and soils were also classified. In the North-West Provinces (district Garhwal) a survey was made of a small forest reserve near the Lansdowne cantonment.

16. The aggregate results of the forest surveys amount to 1,841 square miles as compared with 1,646 executed during the previous year by the same number of parties. The areas of these surveys on the different scales are as follows :—

1,426	square	miles	surveyed	on the	4-inch	scale.
393	"	"	"	8	"	"
22	"	"	"	16	"	"

CADASTRAL SURVEYS.

17. The same number of parties has again this year been engaged on cadastral work, *viz.*, three parties and one detachment in Bengal, two parties in Burma, one in the North-West Provinces, and one in Assam.

18. In Bengal, the three parties were employed in the Western Dooars, in Chittagong and in Orissa, whilst the detachment carried on some special work connected with the lands belonging to the estates of the Burdwan Raj. In the Western Dooars, there were the same difficulties as before to be faced, such as the dense jungle, and the apathy of the people; whilst the unpopularity of the work among the survey establishment, owing to the excessive unhealthiness of the climate and the nature of the country, had increased, rendering it still more difficult to get efficient *amins* to take service there. An area of 234 square miles was cadastrally surveyed. The cadastral survey of the Jalpaiguri district is practically completed, but a section of the party will be required for another year to complete the records. There still remains a large area of forest reserves and culturable lands, all covered with dense jungle, to be surveyed; the former on the scale of 4-inches, and the latter on 2-inches to a mile.

19. In Chittagong, the cadastral survey was continued and covered an area of 469 square miles, whilst that of the Serail *pargana* in Tipperah was completed together with the village records by the same party. The record-writing in Chittagong was made over to the Settlement Department, as it was found that, owing to the complexity of tenures, it was extremely difficult for the survey *amins* to understand, or to write up the *khasras*. The out-turn of this party was considerably reduced by the early setting in of the rainy season.

20. The Orissa party continued its operations in the districts of Pooree and Cuttack. Training schools, where considerable numbers of men were taught field-surveying, were established at certain centres in the districts. The detail surveys were made entirely by local men so trained, and under the supervision of Hindustani and Urya inspectors. In Cuttack the record-of-rights was invariably completed by the same man who surveyed the village. The area surveyed amounted to 687 square miles.

21. Besides the above three parties, a small detachment was employed in relaying the boundaries, as shown on the old settlement maps of 1854, of certain villages in the district of Bankoora, belonging to the estate of the Burdwan Raj, and on the cadastral survey of scattered lands in the district of Burdwan, which had been omitted from measurement during previous seasons.

22. In Lower Burma, an area of 408 square miles was surveyed on the 16-inch scale in Amherst district and 320 square miles in Thongwa, making an out-turn of 728 square miles of 16-inch survey; in addition to this, 164 square miles were surveyed on the 4-inch scale in the latter district. This brings to a close the survey of all the tracts assigned in Thongwa, which aggregate 2,910 square miles; the total cost of this work is ₹5,80,769, which gives a rate of ₹200 per square mile for all the survey operations. About 400 square miles have been traversed in advance for cadastral survey next year in district Amherst. The scheme for the employment of Burmans and Karens as field surveyors has made satisfactory progress. Of the 728 square miles surveyed this year, 54 Burmans contributed 404 square miles and 27 Hindustanis 324 square miles, besides 164 square miles of 4-inch survey. This gives the average out-turn of the Burman as about four-sevenths of that of the Hindustani, which is an improvement on that of last year.

23. The cadastral party in Upper Burma resumed operations in the Mandalay district, and also commenced and completed the survey of the royal lands in Meiktila, which had been specially asked for by the Burma Government. The out-turn was 584 square miles in Mandalay and 563 in Meiktila, or 1,147 square miles in all. In addition to this 714 square miles have been traversed in advance in Sagaing. A successful attempt was made to obtain locally a certain amount of labour for chaining purposes, and thus to save some of the heavy expenditure incurred in importing labour from India. It was accordingly decided that only two men should be imported with each *amin*, and that the other two men required should be obtained locally; after a time this was found to work well, and about 200 local men were employed at daily wages of 4 annas in Mandalay and of 6 annas in Meiktila. About 30 Burman *amins* were employed, and their average out-turn was found to be about five-sevenths of that of the Hindustanis; their work was found to be good in open country, but in the jungles much of it had to be rejected.

24. In the North-West Provinces, the party continued its survey operations in the Garhwal district, and completed those in the Rampur State. The work in Garhwal was carried on by a mixed establishment of Hindustanis from the plains, and of hillmen; but, as the cold climate and mountainous nature of the country did not suit the former class, many of those who had promised to return failed to do so, whilst the hillmen did not come forward in any numbers; the establishment was therefore very inadequate for the work to be performed. The total area of the tract over which the cadastral survey was carried is 299 square miles. In Rampur, 724 square miles were surveyed by a mixed establishment, of which about one-fourth were trained *amins* and the remainder local *patwaris*. The cost-rate per square mile of the Rampur survey is ₹95-10 for the complete operations of traverse, field survey, and record-of-rights.

25. Cadastral operations in Assam were carried on in districts Nowgong, Kamrup, and Darrang, as well as in Sylhet, by an establishment consisting partly of local and partly of imported *amins;* the Hindustani *amins* had writers to assist them in preparing the Bengali records. Some difficulty was experienced in inducing *amins* not belonging to Kamrup to enter that district, in consequence of the prevalence of the disease known as *kala ajar*, which is much dreaded; several men threw up their appointments rather than take up work in that district. The area surveyed amounted to 828 square miles, of which 47 square miles are in Sylhet. The field season was unusually unhealthy, especially in Sylhet, where the establishment suffered much from malarial fever.

26. The areas of cadastral survey completed this year in the different provinces are as follows:—

	Square miles.
Bengal	1,417
Burma	1,875
North-West Provinces	913
Assam	828
TOTAL	5,033

This shows an increase of 252 square miles over the out-turn accomplished by the same parties in 1889-90, and of 197 square miles over that of 1888-89.

TRAVERSE SURVEYS.

27. There were only two parties engaged on special traverse operations, for the purpose of providing an accurate basis for the field-to-field survey by village officials, or other local agency under the Settlement Department. One party was employed in the Central Provinces and the other in Lower Burma.

28. In the Central Provinces, an area of 3,229 square miles was traversed, nearly all of which was in the district of Mandla; part of the country operated in was rugged and unhealthy, which affected the progress of the work. A considerable area still remains to be traversed in the Mandla district, and the party will continue the traverse survey for another year. The details regarding area and cost of the traverse surveys that have been executed in the Central Provinces for settlement purposes during the past six years will be found at page 85. The average cost rate over the sixteen districts completed, covering an area of 51,473 square miles, is R26-11-2 per square mile.

29. In Lower Burma, the traverse survey was continued in the districts of Prome, Hanthawaddy, Tharrawaddy, and Henzada; the work was much scattered and the country was of a very difficult nature for such operations, and the cost thereof is consequently heavy. The area completed was 1,364 square miles, of which only about one-fifth was under cultivation. Although the traverse operations are not yet complete, it has been decided to transfer the survey party that was employed on them to Upper Burma for cadastral operations, and to carry on the skeleton traverse work under the superintendence of the local survey agency, with the aid of a trained officer from the Survey Department.

30. The areas which have been traversed during the year are as follows:—

	Square miles.
Central Provinces	3,229
Lower Burma	1,364
TOTAL	4,593

SPECIAL OPERATIONS.

31. In default of there being two officers available for carrying on the electro-telegraphic longitude operations, the work of observing latitudes was re-commenced on the Madras meridional series from the point where it had been left in the season 1888-89. Seven stations were observed at, the southernmost being on the parallel of 13° and the northernmost on that of 15° 56″.

32. The tidal operations have been continued as usual. Observations by the self-recording tide-gauge have been made at seventeen stations in India, Burma, Ceylon, and the Andaman Islands. Three tidal observatories have been closed and dismantled during the season, the tidal record at them having been completed, and two new ones at Minicoy and Trincomalee have been established.

33. Spirit-levelling operations have been carried on from Rájkot to Bhávnagar, from Sanosra to Port Albert Victor, and from Náydongri to Málkhet, over an aggregate distance of 425 miles.

GEOGRAPHICAL SURVEYS AND RECONNAISSANCES.

34. The very large area of comparatively unknown country, reported as having been geographically surveyed during last year, has been exceeded during

the year under review: the total out-turn for this class of operations amounting to 1,00,848 square miles as compared with 97,792 square miles executed last year. Of this total 41,844 square miles have been mapped in Burma and 59,004 in Baluchistan and Persia.

35. As was the case last year, two field parties, Nos. 11 and 21, have carried on the preliminary survey of Upper Burma on the $\frac{1}{4}$-inch scale, and have furnished surveyors to accompany various military and exploring expeditions The out-turn of the more regular survey work, which is being carried out by districts, amounts to 18,494 square miles.

36. Captain Longe and Lieutenant Gordon accompanied the military expeditions which operated to the north and west of Mogaung, and the latter officer subsequently joined the expedition to the Jade Mines. Arrangements had been made for two surveyors to accompany a column into the Baungshé country, lying to the south of the Chin hills and south-west of Gangaw, but the surveyors, on arriving at the base of operations, found that the expedition had been abandoned for that season. Their time, however, was not wholly wasted, as Mr. Kitchen and the native surveyor succeeded in making a rough reconnaissance of over 2,000 square miles of the Baungshé country from points on its eastern border. A native surveyor, Sher Shah, was attached to another expedition under Lieutenant Burton, which penetrated into the Kachin hills, east of Bhamo, and an area of 1,300 square miles was reconnoitred. The total area mapped by these parties in the above operations amounts to 23,294 square miles.

37. The expedition under the political charge of Lieutenant Eliott, which proceeded from Senbo, above the first defile of the Irrawaddy, to explore the upper branches of that river, was accompanied by Major Hobday. The column marched northwards along the right bank, as far as the confluence of the Malikha or western branch, and the 'Nmaikha or eastern branch, and thence along the right bank of the western branch as far as latitude 26° 15′. From a hill here, the course of the river could be clearly traced through the Kanti country, and as previous reconnaissances had determined its course from its source to the Kanti country, a fair knowledge has now been gained of the western branch throughout its length. From rough measurements taken at the confluence of the two branches, it was found that the 'Nmaikha or eastern branch was wider and deeper; that the water therein was of a colder temperature, from which it may be supposed that it receives a greater volume of snow-water; and that its volume was somewhat greater: so it may be inferred that the eastern branch is the main source of the Irrawaddy. The information obtained regarding the source of the 'Nmaikha was, however, scanty and unreliable. There is reason however to suppose that the eastern branch has not a much longer course than the western one, and that the Lu river of Tibet, instead of running into the Irrawaddy as shown in recent maps, is identical with the Salween river. Major Hobday succeeded in mapping an area of 4,300 square miles of previously unexplored country. The work done during this expedition, combined with that of Sher Shah's alluded to in the previous paragraph, and the explorations of former years, furnishes a very fairly reliable map of the eastern frontier of Burma between the 24th and 26th parallels of north latitude.

38. Further south, two columns also operated on the eastern frontier. One, under the political charge of Lieutenant Daly, started from Lashio, and marching through Theinni State traversed a large area of unknown country lying on the eastern border of the Northern Shan States. This was accompanied by Captain Renny-Tailyour, R.E., and one sub-surveyor, who secured an out-turn of 5,250 square miles of topography. The second expedition, known as the Kyaington-Chiengmai frontier mission, was accompanied by Mr. Kennedy and two sub-surveyors. This small party succeeded in mapping the large area of 9,000 square miles on the $\frac{1}{4}$-inch scale—a very creditable result.

39. The military expeditions on the North-West frontier were each accompanied by small survey detachments. Captain Wahab, R.E., succeeded in mapping 95 square miles on the 1-inch scale of the country on the Miranzai border during the first expedition there. On the close of operations he was detailed to join the Hazara Field Force and during the occupation of the country he was enabled to survey an area of 184 square miles on the 2-inch scale, and to sketch some 360 square miles on the $\frac{1}{4}$-inch scale. Captain Mackenzie, R.E., with one sub-surveyor, joined the Miranzai Field Force during the second phase of oper-

ations and extended the work previously done by Captain Wahab. An area of 160 square miles was surveyed on the 1-inch scale, and 20 square miles were sketched on the ½-inch scale. The results of these surveys have been included in the out-turn given under the head of topographical surveys.

40. In addition to the regular survey of Baluchistan, the field party employed there has again secured a large out-turn of geographical work. During the latter part of 1890, Colonel Holdich, R.E., and Captain Mackenzie, R.E., accompanied the military expedition to the Zhob valley under Major-General Sir G. White, K.C.B., and mapped an area of over 5,000 square miles. In Mekran and on the Perso-Baluch frontier an area of 23,500 square miles was mapped on the ¼-inch scale by Mr. Tate and sub-surveyor Ahmad Ali.

41. Sub-surveyor Imam Sharif, K.B., was deputed from the Baluchistan party, on survey duty in Persia in association with the Intelligence Branch of the Quartermaster General's Department, and was employed there during the greater part of the year under report. He returned with the large out-turn of 30,500 square miles mapped on the ⅛-inch scale.

42. The aggregate areas geographically surveyed, and for the most part now mapped for the first time, are as follows:—

30,500 square miles on the ⅛-inch scale
70,348 " " " ¼ " "

HEAD-QUARTERS OFFICE.

43. The details of work done in the various offices at head-quarters are given in Part III of this Report.

44. The number of new maps and new editions of departmental subjects published during the year amounted to 4,779, of which 4,449 were cadastral maps. The total number of maps issued was 2,08,484 and their value R1,45,245. The cash sales of maps amounted to R12,917. The demand for maps has steadily increased year by year, and the issues are now four times greater than they were ten years ago, the number issued in 1880-81 having been 50,869.

45. In the Drawing Branch, the preparation of maps of Burma on various scales has been the principal work. The second edition of the general map, on the 32-mile scale, has been completed, but the publication thereof has been delayed for want of alterations in internal boundaries, which the Local Government has been asked to supply. A new map of Upper Burma, on the 16-mile scale, which is a great desideratum, has been commenced and has made good progress. The third edition of the 32-mile map of India, with extensions to the east and west, so as to include the limits of Burma and Baluchistan, is still in progress. Considerable additions have been made from the surveys in progress on both frontiers; and to avoid the delay that would take place in engraving the new materials on the copper plates, it is intended to make the necessary additions, including all other existing geographical information of those frontiers, on stone, transfers from the copper having been made for this purpose.

46. Considerable difficulty has again been experienced in dealing with the regular departmental mapping owing to the great increase of extraneous work demanded by various outside departments, which are of such a pressing and continuous nature as to put a heavy strain on this section of the office. The work has increased enormously in the last few years owing to the above cause, as well as to the vast amount of trans-frontier work and the mapping of Upper Burma that has had to be dealt with. The efficiency of the office to meet the demands made on it cannot be maintained without an increase to the staff of draftsmen.

47. In the Engraving Office, good progress has been made with the various provincial maps on the 16-mile scale. The new railway map of India, on the 96-mile scale, is practically completed, but the many alterations required by the Railway Department have delayed its publication. A map of India, on the scale of 128 miles to the inch, has been commenced, and another map, on the 256-mile scale, has been progressed with.

48. In the Calcutta City Survey Office, the drawing of the fair sheets, 235 in number, on the original scale of survey, 1 inch = 50 feet, which are being prepared for reproduction by photo-zincography, is completed, with the exception

of certain boundaries, the survey of which is incomplete. Delay in laying down these boundaries has been caused by difficulty in getting the proprietors of holdings to attend and point out the boundaries. It has been necessary to institute prosecutions for non-attendance, which have had some, effect, but considerable delay is still experienced, and it is estimated that 1,550 holdings now remain for final demarcation. The map of Calcutta for general purposes will be published on the 16-inch scale, and the sheets, 15 in number, are being re-drawn for reduction with the object of producing the map by heliogravure.

49. The work done in the Photographic and Lithographic Office again shows a considerable increase. Out of a total of 7,067 original subjects received for reproduction during the year, 4,376 were cadastral maps, 1,145 were ordinary departmental maps, &c., and 1,546 were miscellaneous subjects for other departments. There was an increase of 284 extra-departmental subjects over the previous year, and this class of work is now much in excess of the regular departmental work, excluding cadastral maps. The total number of copies of maps and various other subjects printed off was 745,993, besides 1,074,280 impressions from type and 3,796 photographic prints, and their value was about R2,08,654, or R8,280 more than last year.

50. The new steam machinery was working throughout the year without any hitch or difficulty, and proved of vast use in dealing with the increased demands, which could not have been met without its aid. Most of the hand-printing presses as well as the machines were fully occupied.

51. The 24-mile map of Afghanistan, and the two railway maps with hills on the 48 and 64-mile scales, noted in last year's report as ready for press, were printed off and published. The completion of the 32-mile map of India (third edition) has been delayed in consequence of the heavy additions of hills in Burma, and with the further addition of hills in Sind, Baluchistan, and Kashmir; the map will probably not be completed till well on in the current year. The 6-inch map of Calcutta in two sheets was published, but further additions are now being made to it for a new edition.

52. Among other departmental maps photo-zincographed and published, may be noticed new issues of the maps of the Madras Presidency, the North-Western Provinces and Oudh, and the Central Provinces, on the 32-mile scale; also of the Presidency and Chittagong Divisions on the 8-mile scale. Nine district maps on the 4-mile scale were lithographed by transfer from the engraved copper-plates, and 239 standard sheets of the Topographical and Revenue surveys were published, exclusive of reprints.

53. The extra-departmental work has again been very heavy, and includes railway and telegraph maps on the 96-mile scale brought up to date; a military map of India on the 32-mile scale; a forest map of the Punjab on the same scale; several large scale maps of the new oil-fields in Burma; and block-plans of the City of Mandalay. Besides the usual weather charts and meteorological diagrams, a new series of charts for the monthly weather reports has been commenced, and will be a steady demand on the office.

54. The out-turn of the heliogravure section also shows a large increase in photo-etched plates, photo-blocks and electrotypes, nearly the whole of which was required for other departments. Seventy plates were reproduced by photo-etching, including 17 plates for the illustration of Mr. Cotes' reports on economic entomology, published by the trustees of the Indian Museum (14 of these plates are being reprinted for Dr. Watt's "Dictionary of Economic Products"), also 34 photo-blocks for the same publication. Twenty-one plates of the technical art series have been printed and issued during the year. Three plates of the outline of the new 24-mile map of Afghanistan were photo-etched; the remaining plate will be done as soon as certain necessary corrections have been carried out in the original. Outside demands which require the utilization of the heliogravure process are steadily increasing. The introduction of photo-block work in half-tones is an important feature of the work of the year, and bids fair to be of immense use in providing a cheap and practical method of half-tone printing suitable for book illustration. Colonel Waterhouse has obtained some ruled glass screens from America, and with these it is hoped that very greatly improved results may be obtained.

55. Colonel Waterhouse was on furlough in Europe for six months, and spent part of his time in making enquiries in England and abroad regarding methods of quick copper-plate printing and new processes of reproduction. He

has made further advances in the process of producing positives direct in the camera as reported last year.

56. The demands on the Mathematical Instrument Office for survey and other scientific instruments were in excess of those of last year, the total number of instruments issued amounting to 64,203, valued at R2,88,337, as compared with 60,128, valued at R2,70,458, issued during the previous year. The heavy demand of the Meteorological Department for the supply of 5-inch rain gauges of an improved pattern to nearly every recording station in India considerably taxed the resources of the office; large indents also for cheap instruments were received from the Local Governments of the Central and North-West Provinces. During the year 63,196 serviceable instruments, valued at R2,59,909, and 3,668 repairable instruments, valued at R60,734, were received into store.

57. In the Trigonometrical Branch Office, Dehra Dun, the Computing section has been engaged in passing through the press volume XIV of the Account of the Great Trigonometrical Survey, containing the final reduction of the principal triangulation of the south-west quadrilateral. Considerable progress has also been made with the synoptical volumes of the several chains of principal triangulation. As has been the custom hitherto, photographs of the sun have been taken on every day on which the sun was visible throughout the year, and the negatives forwarded to the Solar Physics Committee at South Kensington for incorporation in the yearly volumes of the Greenwich observations.

58. In the Drawing Office, Simla, the principal work of the year under report has been the preparation of trans-frontier maps on the scale of 1 inch = 8 miles. A new edition of the Turkestan map, on the 32-mile scale, is in preparation, and several miscellaneous maps, illustrating the military expeditions of the year on the north-west frontier, have been drawn; a new general map of Baluchistan, on the 16-mile scale, has been commenced and is nearly completed.

INSPECTION TOURS OF THE ADMINISTRATIVE OFFICERS.

59. On the 8th April 1891, the Surveyor-General left Calcutta for Madras and returned on the 30th idem, during which time he inspected at Bangalore the office of No. 19 party, which is employed on the forest surveys in that Presidency, and at Madras conferred with the Forest Member of the Board of Revenue and the Conservator of Forests, and discussed the arrangements to be made for the future working of the party, with the view of increasing its annual out-turn and diminishing the cost-rates. On 5th May, the Surveyor-General proceeded to Simla under the orders of the Government of India, to be in personal communication with them, and the opportunity was taken of visiting and inspecting the survey offices that are located there. He returned to Calcutta on 22nd July, and on 3rd September he proceeded to inspect the various field parties recessing in the Madras and Bombay Presidencies. He visited at Bangalore the offices of Nos. 11, 13, and 21 parties, and at Poona those of Nos. 10, 17, and 25 parties, and returned to Calcutta on 28th September. On 3rd October, the Surveyor-General proceeded to Dehra and Mussooree to inspect the offices of the Trigonometrical Branch and of the Forest Survey Branch, and returned to Calcutta on the 23rd idem.

60. The Deputy Surveyor-General, Trigonometrical Branch, proceeded on tour on 11th August 1891, and inspected No. 18 party at Simla and No. 25 party at Poona, and returned to his head-quarters on 27th idem. The recess offices of the other survey parties under his immediate superintendence were located at his head-quarters, and were duly inspected from time to time, *viz.*, Nos. 14, 22, 23, and 24 parties.

61. On the 13th February, the Deputy Surveyor-General, Revenue Branch, accompanied the Lieutenant-Governor of Bengal on an inspection tour to Chittagong, visiting the camp of the settlement officer on the 15th and inspecting the office of the survey party (No. 2, Cadastral) on the 16th; he returned to Calcutta on the 18th idem. On the 31st March he inspected the office of No. 4 party (Western Dooars) at Jalpaiguri, and on the 1st April attended a conference, at which the Lieutenant-Governor of Bengal, the Commissioner of the Division, and the survey and settlement officers were present; the future programme and procedure of the survey party were discussed, and orders were given for increasing the survey office establishment to allow of the more rapid submission of records to the Settlement Department.

On the 16th April he left for Burma, returning to Calcutta on the 16th May. During his tour he inspected No. 7 (Cadastral), No. 20 (Forest), No. 11 (Topographical), No. 3 (Cadastral), No. 21 (Topographical), and No. 12 (Traverse) parties, visiting their head-quarters and camp offices. He also attended a conference at Rangoon, at which the Chief Commissioner and the Financial Commissioner were present, when the future survey operations in Burma were discussed and arranged. He also enquired into the complaints made by the Superintendent of Supplementary Surveys, that delay was caused to that department by the non-submission of traverse plots by the survey party; in consultation with the Director of Land Records and the Superintendent, arrangements were made for their more speedy submission in future.

On the 29th June he met the Director of Land Records, Lower Provinces, at Burdwan, and consulted with that officer and the manager of the Burdwan Raj Estate as to the advisability of allowing the survey detachment to continue working on the estates of the Raj for another season. From the 8th to the 18th July he visited Cuttack, inspecting the survey office of No. 8 party there, and, meeting the Director of Land Records, arranged with him a future programme of survey and prepared estimates in consultation with him and the settlement officer. He also attended a conference, at which the Commissioner, the Director of Land Records, and other officers concerned were present, when arrangements for the revision survey of the irrigated lands were made and other survey matters in Orissa were discussed. From the 3rd to the 10th September, he was again on tour and inspected No. 9 party (Traverse) at Jubbulpore, where he also met the Commissioner of Settlement and Agriculture. From the 15th to the 27th September, he visited Shillong and inspected No. 6 party (Cadastral).

ESTABLISHMENT.

62. The strength of the senior division of the department was settled last year in conformity with the programme of operations that had been arranged, and recruitments have been made during the year under report to bring the establishment up to its full strength. Ten officers have been appointed, three of whom belonged to the Bombay Revenue Survey department, and were transferred under the orders of the Government of India.

63. During the year, five officers of the senior division have retired from the department, all of whom have been associated with it for many years.

Colonel J. Sconce, S.C., Deputy Surveyor-General in charge of the Revenue Branch, was superannuated on attaining the age of 55 years on 2nd April 1891, after a service of 32 years in the Survey Department, during the whole of which time he was employed in the Revenue Branch, and both as an executive and administrative officer has rendered valuable services, especially in connection with cadastral surveys. Colonel Sconce was Deputy Surveyor-General, and superintended the Revenue Surveys for twelve years; the ability and industry he evinced in the discharge of the duties of his office have been highly appreciated by the different Surveyor-Generals he has served under, and it is hoped that his long and meritorious services may meet with recognition from the Government of India.

Colonel D. Macdonald, S.C., Deputy Superintendent, 1st grade, was superannuated on 10th December 1890, after completing a service of 30 years in the department. With the exception of a period of three years when he was Assistant-Surveyor General at the Head-quarters office, he was employed entirely on revenue surveys, and has rendered much useful work as an executive officer.

Colonel W. Barron, S.C., Deputy Superintendent, 1st grade, retired from the service on 19th February 1891 owing to ill-health, which incapacitated him for duty. He joined the department in June 1862, and was employed continuously in the Revenue Branch. His principal services have been in connection with cadastral surveys; the development of the economical system under which the operations of survey and settlement are combined, and in which the survey and revenue officials work together, is largely due to Colonel Barron's labours. He compiled the first hand-book of instructions for conducting such operations in the North-Western Provinces, for which he received the thanks of the Government of India.

Colonel A. Pullan, S.C., Officiating Deputy Superintendent, 1st grade, was superannuated on 31st March 1891 after a service of 28 years in the department. He was employed throughout on topographical surveys, for which his skill as an artist rendered him specially fitted, and he has done good work as an executive officer. His death was reported within a month of his leaving the department from an illness contracted while on active service in India.

Colonel S. H. Cowan, S.C., Deputy Superintendent, 2nd grade, retired from the service on 13th October 1891 after an useful career of nearly 25 years in the Survey Department. He was employed almost throughout his service on revenue surveys, and was an able and experienced officer in cadastral operations.

64. The recruitment of the junior division, which had been contracted for some years under the orders of the Government of India, was authorized up to the existing sanctioned scale during the year under report, and the vacancies have been accordingly filled up. Fourteen officers have been appointed to this division, and three have left it during the year—two by promotion to the senior division and one by retirement.

PART II.

THE OPERATIONS OF THE SEVERAL FIELD PARTIES.

TRIGONOMETRICAL SURVEYS.

PRINCIPAL TRIANGULATION.

BURMA.

No. 24 Party.

65. This party under Lieutenant Close continued the principal triangulation in Burma northward, from the side Omáza-Thantaung, up to which it had been carried in the previous season. The direction of the series from this side, for about fifty miles, has been diverted slightly eastwards from the original meridian of 96°30′ in order to avoid the dense jungle in the plains on the western flank of that meridian, and to enable the stations on both flanks to be fixed on the Karen hills, where the ground is favourable for triangulation. Thus the season's work was mainly in the north-west Karen hills, where the principal difficulty met with was in communicating between the flanks of the series.

Personnel.

Lieutenant C. F. Close, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Mr. T. H. Rendell, Surveyor, 3rd grade.
Mr. J. Hickie „ 4th „
Mr. B. R. Hughes, Assistant Surveyor, 2nd grade.

66. The assistants arrived at Toungoo on the 25th of October, when the preliminary field work was commenced. Messrs. Hickie and Rendell were detailed to select and build forward stations for observation on the east and west flank respectively, whilst Mr. Hughes was entrusted with the building of the stations for the intersected points. The principal observations were commenced by Lieutenant Close on the 18th of November, and continued till the 23rd of February, after which, owing to haze having set in, no further observations to principal stations were possible. Astronomical observations were then taken for azimuth, which occupied Lieutenant Close till the 22nd of March, and the work on the approximate series in advance was continued till the end of April, when the field operations were closed.

67. The result of the season's out-turn is as follows: Horizontal and vertical angles have been taken at nine principal stations, and star observations for determination of azimuth of verification were taken at two stations. The series was extended over a direct distance of 45 miles, embracing an area of 900 square miles. Thirteen principal stations were selected and built in advance of the completed work, extending as far as Mandalay, a distance of 175 miles. This will enable the employment of two observers simultaneously next season, and the final observations will be materially increased. This is a matter of great importance in a country where the conditions of the atmosphere allow of observations being taken during a very limited period.

68. The triangulation has been arranged in two figures, the first a tetragon with a central station, the second a quadrilateral. The northern figure of last year's work was also re-adjusted with the additional angle at Toungoo observed this season.

69. The observations were made with Troughton and Simm's new pattern 12-inch theodolite No. 1, the same instrument that was used the season before. The method of observing was altered from that of the previous season, as intersections were made with the eye-piece micrometer wire, and two sweeps were taken on each face, right and left, on each zero, and the angles were measured on nine pairs of zeros, instead of taking three sweeps on six pairs of zeros. The performance of the instrument may be considered remarkably good, the mean triangular error being $0''{\cdot}36$, between a maximum of $1''{\cdot}07$ and a minimum of $0''{\cdot}01$—the triangular error in the previous season being $0''{\cdot}82$.

70. Lieutenant Close reports as follows:—

"The country through which the triangulation was carried, *i.e.*, the north-western Karen hills, Sulé and Mobyé, is mountainous, densely-wooded, and thinly-populated. With the exception of the road from Leiktho to Yadu, the roads are mere tracks, and it was found that pack bullocks were the best means of transport. Communication was not easy with people who spoke neither Burmese, Shan, nor Karen. North of Sulétaung in the south-west portion of the Shan Plateau, better country was entered—an undulating tract with few trees and isolated hills. The difficult country is now done with, and next year progress should be fairly rapid."

71. The party left the field for recess quarters at Mussoorie on dates varying between the 20th of April and the 4th of May, Lieutenant Close leaving Pyinmana on the latter date. During the recess, the season's observations were computed, and were utilized in calculating the graduation error of the horizontal circle of the theodolite. The results go to prove that the graduation is very accurate, as the maximum mean error of any two divisions 180° apart appears to be about 2″·56, which is equivalent to a linear displacement of one thirteen-thousandth of an inch. Another result of the calculations is to show that an angle measured on six zeros, compared with one measured on nine zeros, may be expected to be liable to an additional error of about 0″·2.

72. A statement, giving the details of the out-turn executed during the year, will be found at page i of the appendix.*

TOPOGRAPHICAL SURVEYS.

GUJARAT, RAJPUTANA, AND SOUTHERN MARATHA COUNTRY, BOMBAY PRESIDENCY.

No. 10 Party.

73. This party has continued topographical operations, during the year under report, in Gujarat and in the Southern Maratha country, Bombay Presidency, as well as in a small portion of Rajputana. The superintendence of the party remained in the hands of Colonel Hutchinson during the field season and up to the early part of June 1891, when he relinquished charge on transfer to No. 17 Party, Bombay Forests, and was relieved by Lieutenant-Colonel J. Hill, R.E., under whom the recess operations of the party have been carried on.

Personnel.

Colonel H. S. Hutchinson, S.C., Deputy Superintendent, 2nd grade, in charge up to 7th June 1891.
Lieutenant-Colonel J. Hill, R.E., Deputy Superintendent, 2nd grade, in charge from 8th June 1891.
Mr. W. Todd, Surveyor, 1st grade.
„ W. Stotesbury, „ 3rd „
„ C. E. Tapsell, „ 4th „
„ W. M. Kelly, Assistant Surveyor, 1st grade.
„ R. R. Dickinson, Assistant Surveyor, 1st grade.
„ W. F. E. Adams, Assistant Surveyor, 3rd grade.
34 sub-surveyors and others.

74. As in the previous year, the party was divided into two sections, one being employed in the Southern Maratha country, and the other in Gujarat. The survey work in Rajputana was undertaken by a small party detached from the section which had been allotted to Gujarat. This detachment commenced field operations on the 15th October, and after the completion of the Rajputana work in the middle of February, it moved southwards and joined the other portion of the Gujarat section which had taken the field between the 15th and 20th November. The Southern Maratha section also commenced field work on the 15th November, and the whole party returned to Poona by the end of May.

75. The total out-turn of the season's work is as follows:—

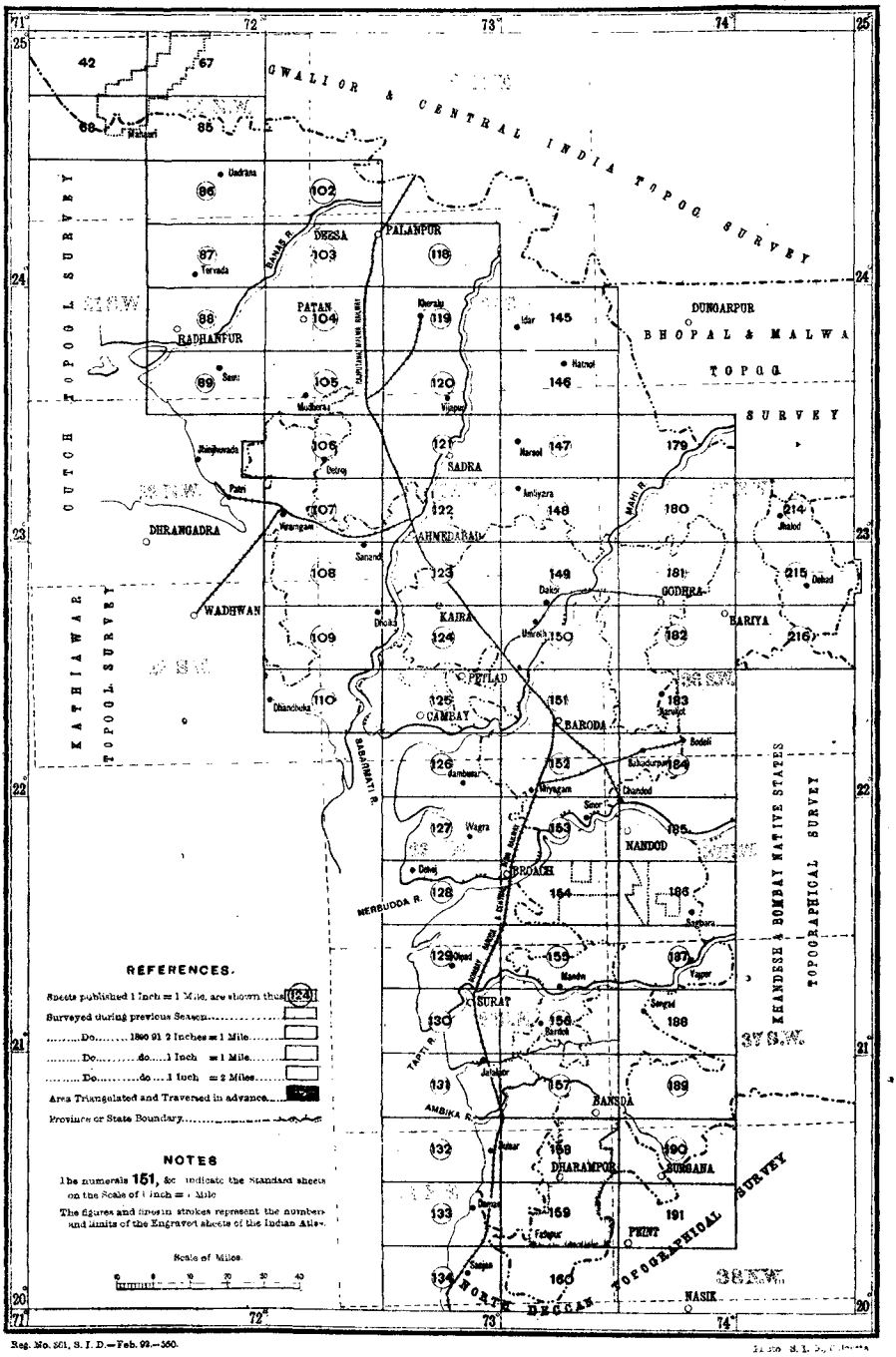
Triangulation, 1,440 square miles, fixing 186 points (including stations).
Detail survey, 2-inch scale, 2,742 square miles.
Ditto 1-inch „ 896 „
Ditto ½-inch „ 925 „
Traversing, 1,226 linear miles, covering an area of 1,727 square miles.

The operations of the different sections will be described separately.

* Lieutenant Close speaks highly of the zeal and ability displayed by Mr. J. Hickie in carrying out the most difficult part of the approximate work.

BOMBAY SURVEY.

INDEX TO THE TOPOGRAPHICAL SURVEY IN GUJARAT. No. 10 PARTY.



Reg. No. 561, S. I. D.—Feb. 92.—350.

North Gujarat and Rajputana Survey.

76. This work was allotted to Mr. W. M. Kelly, and as the climate of this part of the country becomes excessively hot towards the end of March, he was despatched into the field with five of the best sub-surveyors a month before the rest of the party, so as to enable him to get the work done during the most favourable time. At starting, he experienced some delay due to the failure of the Hakim of Sanchor to furnish the promised camel carriage. This, however, was overcome by the kind assistance of the Commissariat officer at Deesa, and by the energetic co-operation of the Hakim, subsequently secured through the influence of the Resident, Western Rajputana States, and the work was successfuly completed. The whole of the country surveyed was very open and clear of vegetation, the main features varying between sand hills, sandy plains, and the salt wastes of the Rann of Cutch and other small isolated ranns, the sandy plains being however surprisingly fertile and populous.

77. The area surveyed included 896 square miles in sheets Nos. 57 (Rajputana survey) and 85 (Bombay survey) on the 1-inch scale, and 925 square miles in sheets 42 (Rajputana survey) and 68 (Bombay survey) on the $\frac{1}{2}$-inch scale, the remainder of these sheets having been surveyed on the 1-inch scale in connection with the Luni river survey during season 1878-79. The survey contains as much detail as the scales admit of, and was tested throughout by Mr. Kelly; 93 linear miles of test lines having been run in the 1-inch work, and 59 linear miles in the $\frac{1}{2}$-inch work. Sheets Nos. 57 and 85 have been finally mapped for reproduction on the 1-inch scale; their reduction by pentagraph for incorporation with sheets Nos. 42 and 68 on the $\frac{1}{2}$ inch scale has also been made, and the whole of those sheets traced for reproduction on that scale.

Gujarat Survey.

78 The work in the southern portion of this district was made over to Messrs. W. Todd and Stotesbury with six sub-surveyors, it being understood that on the completion of the Rajputana work the detachment employed in that direction would be moved southwards into the Gujarat district, and both establishments would work under Mr. Todd up to the close of the season.

79. In sheet 183, the eastern half of which was first taken up (the western half having been surveyed in season 1883-84), the surface of the country is in the former portion thickly covered with jungle and foliage; the ground being intricate and much of it hilly, and in the more cultivated areas covered with large trees which obstruct the view. The climate at the time of starting the work was unhealthy, and one or two of the sub-surveyors and nearly all the *khalásis* were laid up with malarial fever. Later on the health of the detachment improved, but the progress of the work was still slow, as the most efficient sub-surveyors had been sent to the Rajputana work, and this sheet was not completed till the beginning of March. Colonel Hutchinson tested all the sections of this sheet and has expressed himself as much pleased with their accuracy. Of the area surveyed in this sheet Mr. Stotesbury himself did 57·5 square miles, and he has written an interesting description of the hill fort of Páwagad which will be found in the appendix.

80. Sheets Nos. 154 and 186, which could not be completed last field season, were next taken up. The country is densely covered with jungle and it could not have been surveyed earlier in the season, as the forest is at that time filled with an undergrowth of tall reed grass standing 10 and 13 feet high, obscuring the view in every direction. At the time survey operations were commenced there, however, most of the undergrowth had been burnt, and a carpet of ashes covered the ground; the heat was intense, and as the water-supply was bad, the work proved very trying. Besides surveying 47 square miles himself, Mr. Stotesbury tested the work done by the sub-surveyors during the season in these sheets, together with what they did in the same sheets during the previous year, both by *in situ* examination, and by 120 linear miles of test lines, and found it very satisfactory.

81. In sheet No. 188, the survey of which was undertaken by Mr. Kelly with his detachment from Rajputana in the latter end of February, forms a marked contrast to that to the north of it, being fairly free from jungle; but the climate is unhealthy, and there was a good deal of fever in the detachment in the beginning of March. The northern half of the sheet consists of generally undulating ground

intersected with ravines, studded with isolated hills, and fairly easy to survey. In the southern half of the sheet, there is a plateau rising about 1,500 feet above the general level of the country, which averages 600 feet above sea-level. Besides surveying a section of 68 square miles in this sheet, Mr. Kelly checked the work of the sub-surveyors by running 89 linear miles of traversing and found it satisfactory. The work was completed by the middle of May with the assistance of a couple of sub-surveyors besides those he brought down with him from Rajputana. In all 1,083 square miles were topographically surveyed on the 2-inch scale by this section.

Sheets Nos. 154, 186, and 188 have been finally mapped on the 2-inch scale, and the drawing of sheet 183 is well advanced.

Southern Maratha Survey.

82. Mr. Tapsell, with Mr. Adams and 15 sub-surveyors, continued the topographical survey, on the 2-inch scale, of the Southern Maratha country, and Mr. Dickinson was told off for the triangulation. The topographical detail work of sheets Nos. 273, 274, 304, and what remained of sheet No. 330, was completed; and the traverse work was extended over sheets Nos. 272, 273, and 274, comprising an area of 1,727 square miles.

83. This country is mainly flat, open and easy of survey. One intricate and interesting range of hills crosses sheet No. 274 from south to north and contains the well known falls of Gokak. The area of topographical work executed by this detachment during the season is 1,659 square miles. It was tested by a close examination *in situ*, as well as by 199·5 linear miles of test lines, and was found excellent in quality and up to the standard of previous years' work.

84. Before taking up the triangulation, Mr. Dickinson undertook the mapping of the South Maratha Railway on to all the old sheets of Deccan survey that had been surveyed and published previous to the construction of the line, commencing the work from Poona and finishing at Miraj. He then extended the triangulation over sheets Nos. 242, 272, and 273, accomplishing an out-turn of 1,440 square miles. The mathematical results of this work are good, both as regards angular and linear errors. The final mapping of sheets Nos. 274, 304, and 330 has been completed.

85. The recess office of the party was inspected by the Surveyor-General in September 1891. The records were found in good order and the recess duties progressing satisfactorily. The drawing of the fair standard maps is deserving of high commendation; they are executed in a highly artistic and effective style, while the field sheets give evidence of the survey having been carried out with care and accuracy. The general efficiency of the establishment was all that could be desired.*

MERGUI DISTRICT, LOWER BURMA.

No. 13 Party.

86. It had been intended to discontinue the operations in the Mergui district after the field season of 1889-90. The Burma Government, however, applied for the retention of the party for another year, and this having been sanctioned, arrangements were made to take the field again in November 1890, with a view to carrying on the survey of the tin-bearing tracts in the Mergui district.

Personnel.

Mr. A. D'Souza, Officiating Deputy Superintendent, 3rd grade, in charge.
" A. J. Gibson, Surveyor, 1st grade.
" G. Vander Beek, Assistant Surveyor, 1st grade.
" P. White, Assistant Surveyor, 1st grade.
" R. F. Warwick " " "
" J. A. Higgs " " "
" M. Gastaud " " "
7 sub-surveyors and others.

* Regarding the European Assistants, Colonel Hill reports as follows:—

"Mr. Todd supervised all the work done in Gujarat, and his arrangements throughout the season were good, and the work completed, satisfactory."

"Mr. Stotesbury is a first-rate assistant, intelligent active, hardy and willing, whilst he is an excellent topographical surveyor and draftsman. His individual work and influence amongst the surveyors are highly appreciated."

"Mr. Tapsell has maintained throughout the season an excellent supervision of his work, and has secured a capital out-turn; he is a most valuable assistant."

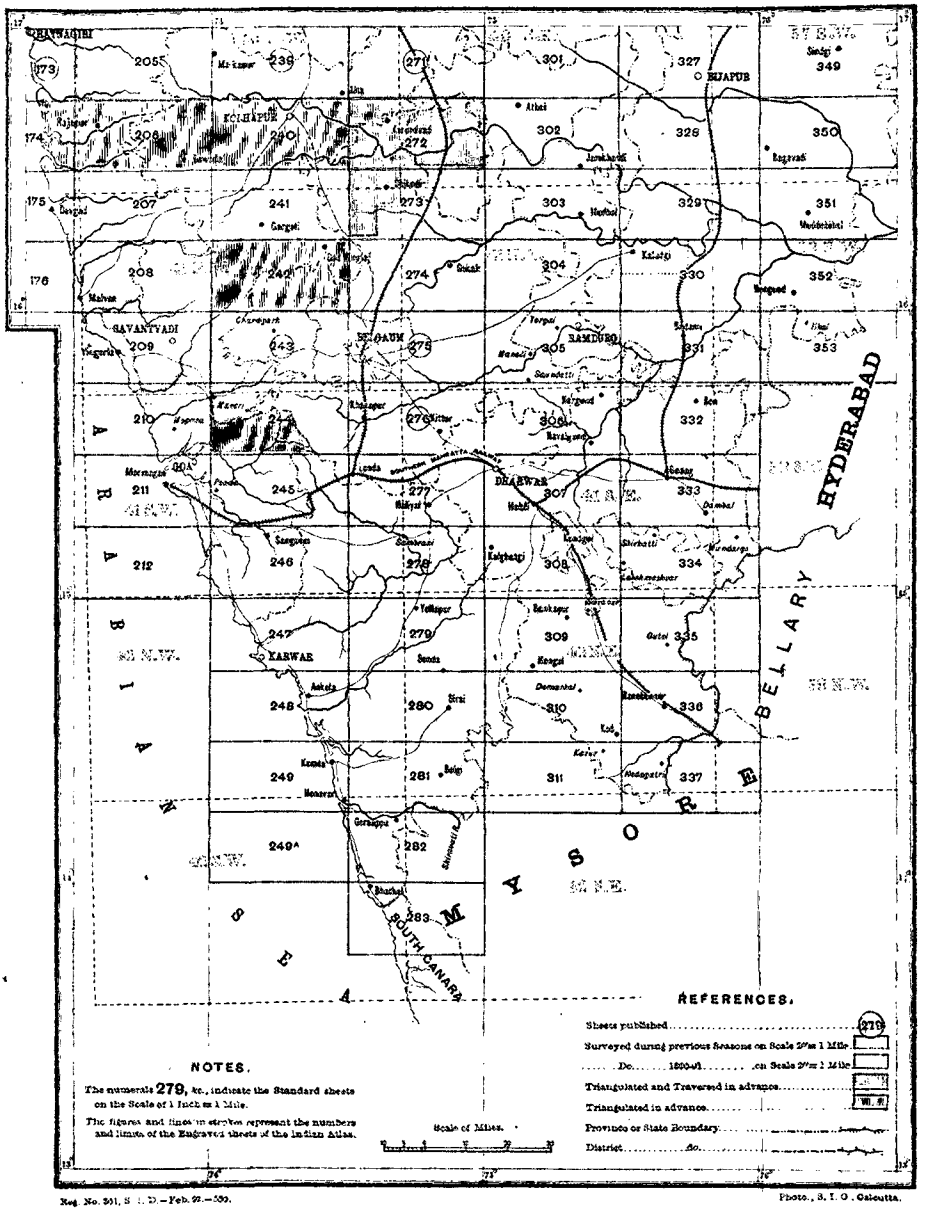
"Mr. Kelly deserves the greatest praise for the energy, zeal, and perseverance with which he completed the Rajputana survey, which is of excellent quality."

"Mr. Dickinson continued to be a very good assistant, and has worked up to his previous reputation."

BOMBAY SURVEY.

INDEX TO THE TOPOGRAPHICAL SURVEY IN SOUTHERN MARATHA COUNTRY.

No. 10 PARTY.



NOTES.

The numerals **279**, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.

The figures and lines in circles represent the numbers and limits of the Engraved sheets of the Indian Atlas.

Scale of Miles.

REFERENCES.

Sheets published 279

Surveyed during previous Seasons on Scale 2″ = 1 Mile ..... [ ]

..... Do. ..... 1000 ft. ..... on Scale 2″ = 1 Mile ..... [ ]

Triangulated and Traversed in advance ..... [ ]

Triangulated in advance ..... Vol. II.

Province or State Boundary .....

District ..... do. .....

Reg. No. 361, S. D.—Feb. 92.—550.

Photo., S. I. O., Calcutta.

87. The party left recess quarters at Moulmein on the 4th of November 1890, and remained in the field until the 28th May 1891, when it returned to Mergui, and thence to Bangalore, the new recess quarters.

88. It had been arranged that the coolies and *khalásis* who had been recruited at Hazaribagh should leave Calcutta by the steamer of the 28th October, so as to reach Mergui a week after the arrival of the party from Bangalore, but, owing to the dilatoriness of the men, they failed to catch the steamer and were thus delayed in Calcutta; a further delay in Rangoon would have taken place (the service between that port and Mergui being a fortnightly one), had it been not for the loan of the steamer *Mergui* which was obtained through the Financial Commissioner. The men on their arrival at Mergui were despatched by boats to Bokpyin, where they awaited the survey party. This place being centrally situated with regard to the country to be surveyed, and being also a calling station for the coasting steamer plying between Mergui and Maliwun, was made the basis of operations. The time spent at Mergui, whilst waiting for the coolies, was not entirely lost, for guides and interpreters had to be engaged, the obtaining and transporting of sufficient supplies had to be organised, and huts had to be erected at suitable places for the storage of the supplies. Mr. D'Souza held a conference at Mergui with the Deputy Commissioner and the District Superintendent of Police, when it was arranged that the head *chetanjies* of sub-divisions of Bokpyin and Lynia should be placed under his orders with respect to furnishing the detached parties with extra coolies, provisions, and other requirements, when possible, in the populated portions of the country; in other places the survey had to be entirely dependent on its own resources. Instructions were also issued to the head constables of each *thana* and outpost to render every assistance; Indian police constables who were conversant with the Siamese language were also provided.

89. The keeping up of a proper supply of provisions to the several detached camps in a country where local supplies were very scanty or altogether wanting, and where communications, except by boat, did not exist, was a source of great difficulty and anxiety. The provisions were obtained through the Agent of the British India Steam Navigation Company at Mergui and were distributed to various depôts. The main depôt was established at outer Bokpyin, and four branch depôts at Hangpro, Hangachin, Klongkitong and inner Bokpyin; two or three boats were attached to each depôt for keeping up communications and for the carriage of supplies. The use of elephants for transporting provisions overland not having proved a success last year, coolies were employed between the depôts and the detached survey camps. As the work progressed inland, however, the usual difficulty attending the use of coolie transport over long marches was felt, *viz.*, the inability of the men to carry much more than the food required for themselves on the march; this difficulty was moreover increased by the nature of the country, the coolies often losing their way in the dense forest, and thus taking longer over their march than the actual distance necessitated. In January, complaints about the inability of the coolies to keep the camps supplied became so frequent that it was evident that the depôts must be moved to more suitable positions; four new sites were accordingly selected at Lynia, Hangpro, Tophan, and Pla-ân, where huts were built and tracks cleared through the jungle to open up communications with the camps: communication between the main and branch depôts was also much facilitated by the use of a steam launch, the purchase of which has been sanctioned by the Government of India; it also enabled the officer in charge to visit the various sections of the work with ease and rapidity. The launch is a very good boat and has proved a great success, and now that it has been decided to again send a survey detachment to complete the two districts, the purchase will prove to be a very economical arrangement.

90. Field operations were commenced on the 20th November 1890 and closed on the 28th May 1891. The district to be surveyed on the 1-inch scale lay between latitudes 10° 45′ and 11° 30′ and longitudes 98° 30′ and 99° 0′, covering an area of about 1,000 square miles, comprised in sheets Nos. 214, 215 and 216, portions of which had been completed last year. To each assistant was allotted an area of about 75 square miles; he was despatched fully equipped and with a month's supply of provisions to the depôt nearest his work, whence he had to march inland. The experience gained in the previous year greatly assisted the surveyors in taking up their work; those whose work was in the vicinity of the

coast had little trouble in reaching their ground, as tracks had in many places been already cleared by the triangulators, but it was otherwise with those whose work was situated inland, and many of them had considerable difficulties to encounter before they could commence field operations.

91. The out-turn of work completed was 930 square miles of topography. No triangulation was carried on, as a sufficient number of points had been fixed the year before. A few hills were cleared with a view to connecting part of last year's work with the stations of the South-East Frontier series, but the necessity of constantly superintending the detail surveyors, and of being on the spot to look after the transport of supplies, precluded the possibility of the observations being made by Mr. D'Souza, and there was no one else available to do it.

92. The country in which operations were carried on very much resembled that surveyed and described last year, being a succession of rugged hills and valleys covered with impenetrable forest, and broken up by numerous creeks and inlets fringed with thick mangrove swamps. The density of the jungle and the size and height of the trees proved great impediments to the progress of the work, and necessitated the clearing of every hill top before survey operations could be commenced. To avoid this labour the surveyors frequently adopted the plan of constructing platforms in the trees several feet from the ground, but from these elevated positions it was generally impossible to follow the run of the streams and nullahs, owing to the density of the jungle, and these had, as a rule, to be traversed. With the exception of those mentioned in last season's report, the country is devoid of roads or even footpaths. Those cut by the surveyors are now being made use of by rattan-cutters and garjan oil extractors, and it would appear that a few good roads cut through the jungles would go far towards opening up the country to settlers coming over from Siam.

93. Mr. D'Souza reports as follows on the nature of the country surveyed :—

"The Chung-Pi range of hills, the highest in the portion surveyed, rises to a height of 2,750 feet above sea-level, and runs due north and south for a distance of about 15 miles, ending abruptly on the coast in a prominent headland, visible for miles out at sea. To the east of this range lies another, the highest point of which, Klongtophat, rises to a height of 2,260 feet above sea-level. This range runs in a southerly direction till it meets the Khow-than-dung range, and from these break off minor spurs, all of about the same height and densely covered with jungle. From the pass where the Khow-than-dung and Klongtophat meet, two principal rivers take their sources, the Klongkra and the Lynia. The former flows in a southerly direction, and meeting with the Plyingan, finally falls into the Pakchan river. The latter flows for 70 miles in a northerly direction and empties itself into Whale bay. This river was found navigable by the launch up to Lynia, by boats to Tophan, and from thence to Pla-an only by canoes or small dugouts. About midway between the mouth of the Lynia river and the town of that name is a whirlpool, called by the Natives 'Wajidway,' dangerous for boats to cross, except at certain periods of the tide. Lynia and Bokpyin are the two chief towns in this sub-division of the Mergui district; the former, with a large population, scattered over a long distance on the banks of the river, the inhabitants being chiefly Siamese, with a few Burmese and Chinamen. There are two villages of the name of Bokpyin, the outer and inner. The former is situated on the coast, and consists of a fishing village of some 50 huts, the inhabitants of which are principally Malays, whose chief occupations are fishing and the manufacture of salt-fish and *Napi*; inner Bokpyin is situated some four miles inland."

94. No fresh discoveries of tin were made during the survey operations, but a number of old workings were found in the jungle and noted on the map. These are merely surface washings, which must have been worked years ago. Indications of tin, however, were found almost everywhere, but in such small quantities as to be hardly worth working.

95. Sickness prevailed to a great extent throughout the period of field operations, the native establishment especially suffering greatly from fever, dysentery, and ulcers. The average proportion on the sick list throughout the season amounted to 10 per cent., and there were 29 deaths.

96. During the recess the computations of last season's work have been completed, three fair maps were drawn for publication and one preliminary chart of triangulation. In addition to the regular mapping, tracings of the entire two seasons' field work have been prepared for the Geological Survey Department.

97. At the close of the recess season the party was broken up and absorbed among other parties, with the exception of a small detachment under Mr. Gibson, which is left to continue the survey of the tin-producing areas on the

BURMA SURVEY.

INDEX TO THE TOPOGRAPHICAL SURVEY IN DISTRICT MERGUI.

No. 13 PARTY.

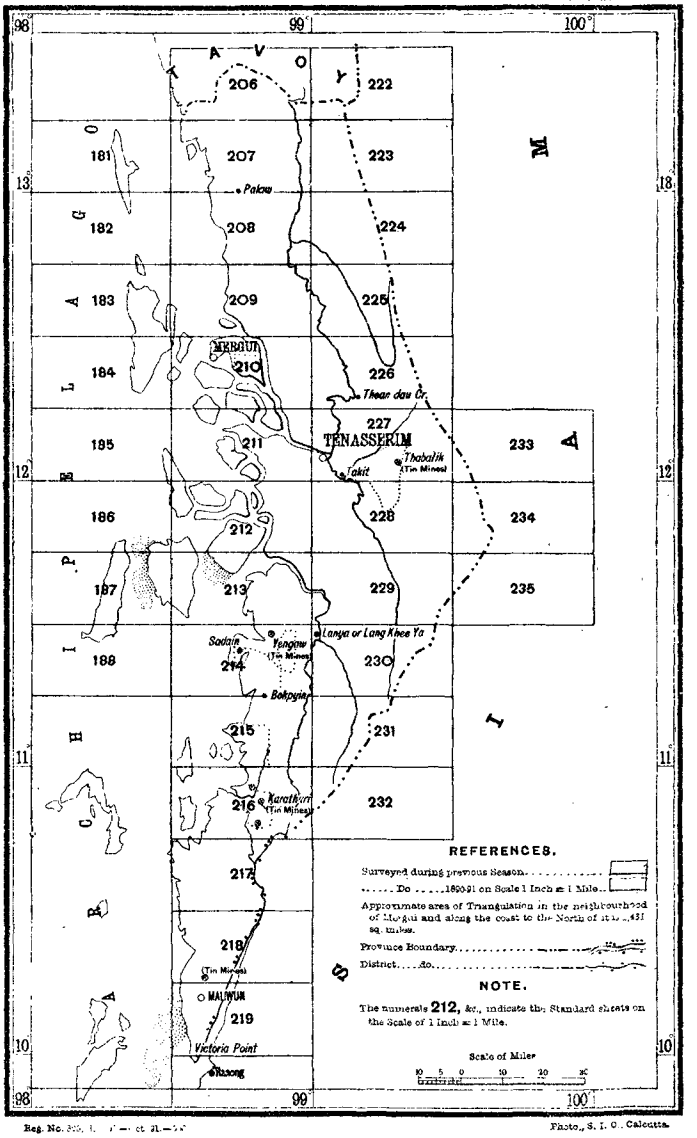


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Photo., S. I. O., Calcutta.

Tenasserim river and in the Maliwun district, and also to traverse the Pakchan and Tenasserim rivers.

98. The recess office of the party was inspected during September at Bangalore by the Surveyor-General, who found the state of the records and the style of the mapping all that could be desired.*

BALUCHISTAN.

NO. 15 PARTY.

99. During the year under report, detachments from this party have been largely employed on geographical reconnaissances in connection with the various expeditions on and across the North-Western Frontier. The extension of the regular topographical work of the Baluchistan survey, undertaken by the party, consisted of—

Personnel.

Lieutenant-Colonel T. H. Holdich, R.E., Deputy Superintendent, 2nd grade, in charge up to 1st April 1891.
Captain R. J. H Mackenzie, R.E., Deputy Superintendent, 4th grade, in charge from 2nd to 16th April and from 22nd June 1891.
Mr. T. E. M. Claudius, Surveyor, 3rd grade, in charge from 17th April to 21st June 1891.
Mr. E. A. Wainwright, Surveyor, 4th grade.
„ E. Graham, Assistant Surveyor, 1st grade.
„ G. P. Tate, „ „ „ „
Yusuf Sharif, Khan Bahadur, Assistant Surveyor, 3rd grade.
Hira Singh, Rai Bahadur, Assistant Surveyor, 3rd grade.

Sub-Surveyors.

Imam Sharif K. B., Ahmad Ali, Abdul Gaffar, Hussein Baksh, Sheik Mohidin, Asghar Ali, Jaffar Ali, Nizamuddin, Mohamed Nagi, Madat Khan.

(1) The completion of the Dera Ghazi Khan and Quetta triangulation. This was entrusted to Mr. Wainwright, who completed the series as far as the Khojak range, and also effected a junction with the Kalat series; the season's work covering an area of 960 square miles.

(2) The extension of the triangulation commenced in 1888-89, along the parallel of 26° N. latitude. This work was entrusted to Mr. Graham, who, on account of the many difficulties he encountered, and from political causes, was unable to carry out his programme in its entirety. He however secured an out-turn of 7,900 square miles of triangulation, and an extract from his report will be found in the appendix.

(3) The completion of the 2-inch to the mile survey around Quetta, of which 29 square miles remained. This was carried out by sub-surveyor Jaffar Ali.

100. A survey detachment from this party composed of the following:—

Lieutenant-Colonel Holdich, R.E., in charge,
Captain Mackenzie, R.E.,
Sheik Mohidin and Asghar Ali, sub-surveyors,

accompanied the Zhob Valley Field Force under the command of Major-General Sir George White, K.C.B. Colonel Holdich accompanied the column under Sir Robert Sandeman, Agent to the Governor General, Baluchistan, and Captain Mackenzie with the two sub-surveyors, joined Sir George White's column. This party remained in the field from early in October 1890 until December 12th, 1890. It accomplished the reconnaissance of some 4,000 square miles on the ¼-inch scale, and 1,359 square miles on the ½-inch scale, whilst the triangulation was extended north of the Kundar valley: the above being all over country previously unexplored. A special report on the country operated in by the Zhob Field Force, by Lieutenant-Colonel Holdich, R.E., has been separately printed.

101. Meanwhile, Imam Sharif, K. B., had been deputed to Persia on special duty, and the services of Hira Singh, R. B., had been placed at the disposal of

* Of the Assistants Mr. D'Souza says:—
"Mr. A. J. Gibson succeeded in completing, under very great trials and hardships, the survey of 105 square miles of a very difficult piece of country. I have therefore much pleasure in commending him for his hearty co-operation, zeal, and energy."
"Mr. G. A. Higgs has worked zealously and well, and the successful completion of the season's programme is in a measure due to the excellent services rendered by him."
Messrs. Warwick and P. White are also favourably reported on. The sub-surveyors are all well mentioned.

the Quarter Master General in India for exploration work. Imam Sharif has practically been employed on this special work for the whole year, and has returned with the large total of 30,500 square miles of reconnaissance on the scale of 8 miles to the inch. Hira Singh rejoined the party on the 17th of January, having been unable, from political causes, to carry out the work required.

102. Early in April, Captain Mackenzie, R.E., with sub-surveyor Hussein Baksh, proceeded to join the second Miranzai expeditionary force: details of the work accomplished with that force will be found under the head of geographical surveys. A re-survey of portions of the Zhob valley, and some additions in the neighbourhood of Yusuf Kach, were completed by sub-surveyor Jaffar Ali, after Captain Mackenzie had joined the Miranzai expedition. In all, about 1,000 square miles on the $\frac{1}{4}$-inch scale, and 380 square miles on the $\frac{1}{8}$-inch scale, were completed by the sub-surveyor.

103. Early in December Mr. Tate accompanied Sir Robert Sandeman on a tour through Southern Baluchistan, and completed about 108 miles of route survey between Las Bela and Panjgur, with 1,500 square miles of reconnaissance on either side of the road, on the $\frac{1}{4}$-inch scale. On the 1st of April his services were placed at the disposal of the Political Department for employment in the Kalat State.

104. At Sir R. Sandeman's request sub-surveyor Ahmad Ali was deputed to meet him at Panjgur for survey purposes. The sub-surveyor left Quetta on the 27th of December 1890, and on the 27th of June 1891, returned with a geographical survey based on triangulation, of 22,000 square miles, on the $\frac{1}{4}$-inch scale, of country on the Perso-Baluch frontier, of which we possessed very meagre information. He displayed considerable tact, energy and perseverance in successfully accomplishing the work he was entrusted with; an extract from his report will be found in the appendix.

105. A survey, on the scale of 2 inches to the mile, of the country lying between Kach and Mangi, on the Sindh-Pishin Railway, was undertaken and completed by Mr. Claudius, assisted by Yusuf Sharif, K. B., and Hira Singh, R. B. This special work was required for a new alignment of the railway in that section. The necessary triangulation was commenced by Mr. Claudius on the 18th of May; the detail survey, comprising an area of 47$\frac{1}{2}$ square miles, was completed on 14th of June, and the fair map despatched for reproduction on the 7th of August.

106. By the completion of the main series of triangles which has been carried westward from the Great Indus Series of the Great Trigonometrical survey a secure base has been fixed on the Khojak range for an extension of the triangulation westwards when required. The number of points also fixed to the northward in the Zhob valley work, will allow of an extension being made in that direction.

107. The total out-turn of work for the season is as follows:—

	Square miles.
Triangulation	8,920
Topographical Survey, 2-inch scale	76$\frac{1}{2}$
,, ,, $\frac{1}{4}$-inch ,,	1,739
Geographical ,, $\frac{1}{4}$-inch ,,	28,504
,, ,, $\frac{1}{8}$-inch ,,	30,500

108. During the recess the greater part of the arrears of mapping which had accumulated owing to large demands for field work have been cleared off, as 22 fair standard sheets and four preliminary maps have been submitted during the year for reproduction, whilst two sheets also have been compiled for the new map of Baluchistan: the computations have been all completed.

The health of the party, especially towards the end of the recess, has been anything but satisfactory; fever and other ailments having been very prevalent, as was the case this year throughout the Quetta district.*

* The officer in charge reports highly of the services of the Assistants.

Mr. Claudius has had a very large share in the management of the party, and has kept up his previous reputation for zeal and ability.

Messrs. Wainright and Graham, with Yusuf Sharif, K. B., and Hira Singh, R. B., are also favourably mentioned, as well as sub-surveyor Jaffar Ali. Sub-surveyors Imam Sharif, K. B., Ahmad Ali, Abdul Gaffar, Hussein Baksh, Sheik Mohidin, and Asghar Ali, were all favourably reported on by the various officers under whom they served, whilst detached from the party on special duties.

PUNJAB SURVEY.

INDEX TO THE SURVEY OPERATIONS IN THE HIMALAYAS.

No. 16 PARTY.

HIMALAYAS, PUNJAB.

No. 18 Party.

109. On Colonel Tanner retiring from the service, after having superintended the operations of this party for several years past, Major St. G. Gore, R.E., assumed charge on the 30th of October 1890, Captain Bythell, R.E., being posted to it as an Assistant on the 1st November.

Personnel.

Major St. G. C. Gore, R.E., Deputy Superintendent, 3rd grade, in charge.
Captain W. J Bythell, R.E., Officiating Deputy Superintendent, 4th grade.
Mr. C. D. Potter, Surveyor, 4th grade.
„ W. Robert, Assistant Surveyor, 1st grade.
„ W. A. Fielding, ditto, ditto.
„ P. F. Prunty, ditto, ditto.
„ R. W. Senior, ditto, ditto.

Sub-surveyors.

Shah Nasiruddin, Atma Singh, Wahid Ali Khan, Ramsaran, and 29 others.

110. The nature and scope of the operations of this party were mentioned in the General Report for last year. The only modification which need be noted is the cessation of the traverse operations to fix *mauza* and *tikka* trijunctions, the whole of the work of this nature which had been called for, having been completed and the plots submitted to the local authorities.

111. The party took the field early in November and remained at work until the end of June, with the exception of one detachment, which was engaged on the survey of Bara Bangahal, and which did not reach Simla, after completion of the work, until the end of July. The season was a particularly unfavourable one for surveying in the hills. The snowfall, with accompanying bad weather, was abnormally heavy throughout the winter and, being succeeded by a dull and cloudy summer, the snow remained on the higher ground until the rains to as low a level as 11,000 feet—an almost unprecedented occurrence. The result was that a certain amount of the detail of the higher ground in Kulu had to be left unfinished until a more favourable opportunity.

112. The British tracts were surveyed, as heretofore, on the scale of 4 inches = 1 mile, with the exception of Bara Bangahal, the survey of which was added to the programme of the season's operations at the special request of the local authorities. This inhospitable tract (a short account of the survey of which will be found in the appendix) is so rugged and mountainous, and has such a small cultivated area, that it was determined to survey it on the smaller scale of 1 inch = 1 mile. The survey of the Native States was continued on the 2-inch scale.

113. The area topographically surveyed during the season under report, in the different localities, is as follows:—

Localities.	Scale.	Area in square miles.
District Kángra	4-inches = 1 mile	272
Ditto	1-inch = 1 „	254
Simla Hill States	2-inches = 1 „	458
	TOTAL .	984

114. The very considerable area of 1,446 square miles has been triangulated in advance for detail survey, 476 square miles being for 4-inch, and 970 square miles for 2-inch topography. With the exception of a small increase in the cost of the 4-inch detail survey, owing to a short field season in Kulu, there is a very considerable decrease in the cost rate in all classes of survey.

115. For the Forest Department in Kángra, 20 complete forest blocks and parts of four others have been surveyed. These, with the exception of one which is under the Deputy Commissioner of Kángra, have been permanently demarcated with distinguishing pillars at the salients. In Kulu the number of demarcated blocks surveyed during the year, either wholly or in part, amounts to 22, while in the Simla Hill States 40 forest blocks in Hindur State, 21 in Baghal, 5 in Kahlur, 2 in Kuthar and 1 in Kunihar, 69 in all, have been surveyed. This brings the total number of forest blocks surveyed by this party up to date to 298 in British territory, and 244 in Native States.

116 Four native soldiers have been under instruction in surveying during the year. Two of these were selected as usual from among those who had passed the Roorkee course. The other two, however, were, at the request of the Quarter Master General, sent direct from the Assam Military Police, without any previous training, to be taught surveying and reconnaissance, with a view to their being utilised for survey work in expeditions on the eastern frontier. The experiment has not been very successful as the men were entirely ignorant of surveying, and their two years' course will be much too short to fit them to take up independent reconnaissance work.

117. As mentioned in last year's report, the work of fixing prominent snowy peaks in Bhutan, with a view to elucidate the geography of that little known region, was prosecuted by Sub-surveyor Wahid Ali from the trigonometrical stations in the neighbourhood of Shillong. The weather was excessively unfavourable, and he was only able to observe from five stations. He, however, succeeded in fixing a fair number of peaks, the farthest of which lay at a distance of more than 220 miles from the point of observation.

118. The programme of work for the coming field season, which has been approved by the Local Government, is as follows:—

The triangulation will be carried on in Kángra, Kulu, Mandi, and the Simla Hill States. The detail survey will be continued on the 4-inch and 2-inch scales in Kángra proper, Chota Bangahal, and Simla Hill States; also the re-survey of as many of the forests in the Simla Hill States on the scale of 4 inches to 1 mile as can be taken up. There will be no detail survey in Kulu next season, as it is intended to close field operations in April, so as to enable the party to take the field in the following season in September and October.

119. The recess office of this party at Simla was inspected by the Deputy Surveyor-General in August, who has suggested some changes in its management to avoid in future the accumulation of arrears which has somewhat hampered its progress in the past, under its late Deputy Superintendent, Colonel Tanner. The arrears seem to be due chiefly to the too liberal employment of young native sub-surveyors, who have been entertained in larger numbers than the existing European staff could deal with. These sub-surveyors, being inexperienced and new to the work, required a great deal of supervision in the field, and proved for the most part quite useless in recess, consequently the greater number of them were allowed to go away on departmental leave and the recess work fell into arrears. Another cause was the scattered nature of the work and the great variety of the operations included in the programme of this party, for, in addition to the forest and ordinary topographical work on three different scales, it has been occasionally called upon to send a detachment for fixing survey peaks in Bhutan and Nepal, and sketching some of the ground in those districts adjacent to our frontier. In consultation with the present Deputy Superintendent arrangements have been made which, it is hoped, will not only prevent such arrears occurring again, but will gradually clear off those at present existing.*

INDUS RIVERAIN, PUNJAB.

DETACHMENT.

120. This detachment was formed from No. 1 party, which was abolished at the close of season 1889-90, for the purpose of undertaking a special survey which had been asked for by the Punjab Government, of a portion of the river Indus, where it forms the boundary between Dera Ghazi Khan district and the Bahawalpur State. The object of the survey was to afford the means of laying down a fixed line of boundary between the district and the State, with a view to avoiding the frequent disputes, which, under prevailing regulations, were constantly arising and causing considerable administrative inconvenience.

Personnel.

Mr. J. S. Pemberton, Surveyor, 1st grade, in charge.
11 sub-surveyors and others.

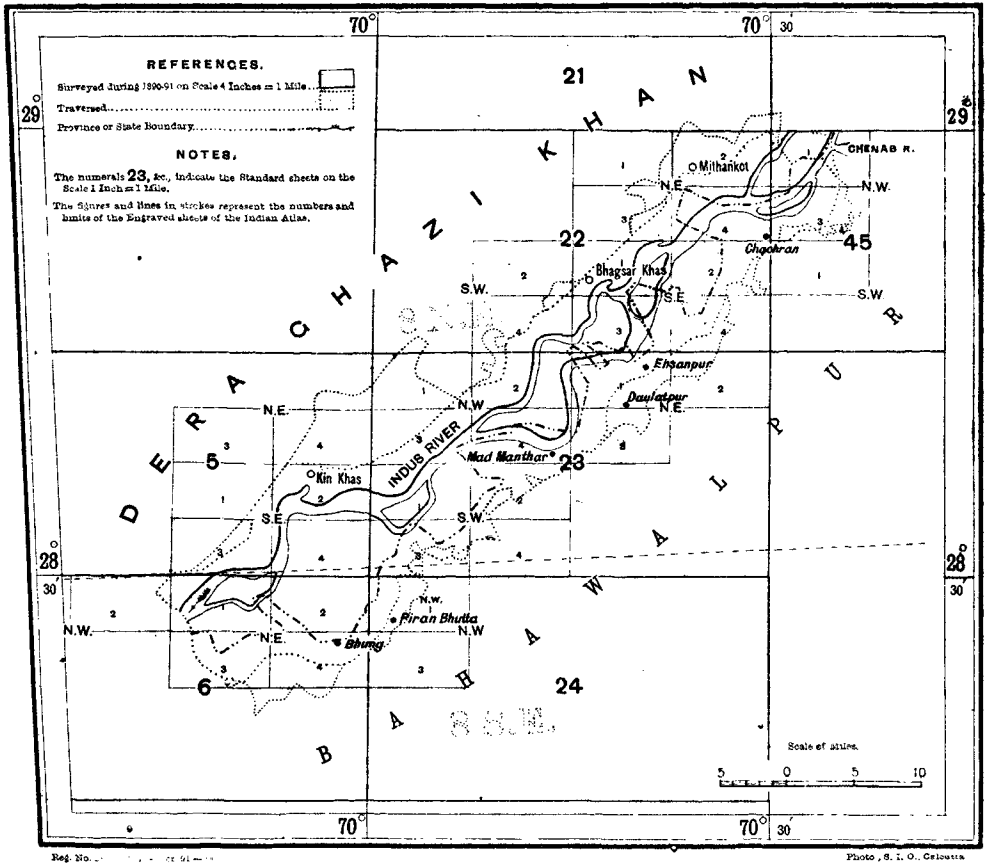
121. Field work commenced on the 19th of November 1890 and was continued to the 11th of April 1891, when the detachment returned to recess quarters

* Major Gore reports favourably on the work of all his European Assistants. Sub-surveyors Ram Saran and Dan Singh are also especially mentioned for good work.

PUNJAB SURVEY.

INDEX TO THE INDUS RIVERAIN SURVEY IN THE PUNJAB.

INDUS RIVERAIN DETACHMENT.



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Photo, S. I. O., Calcutta

at Simla. The programme of operations, which was fully carried out, was as follows:—

(1) The traverse survey of both banks of the river with a line of adjacent *mauzas* limited to a distance of 1½ miles from either bank.

(2) A traverse survey of the actual boundary between District and State (which, except for short distances, was quite distinct from the river) with a line of *mauzas* limited to 1½ miles on either side of this boundary.

(3) A detail survey on the scale of 4 inches to the mile of the river and the adjacent country, confined to the limits of the *mauzawar* survey described above.

122. The traverse work was connected with a continuous line of *mauza* trijunction platforms, above the sphere of river action, which were taken up by traverse and shown on the old Revenue Survey maps of 1872 and 1874; the object being, first, to afford an easy means of incorporating the present with the old survey; and, secondly, to facilitate the laying down of any boundary (but especially any portion of the State boundary) which might hereafter be washed away. Whenever practicable boundary pillars were adopted as traverse stations.

123. The total area comprised within the limits of the *mauza* trijunctions referred to above, amounted to 693 square miles; but of this only 552 square miles were surveyed in detail. As on starting field operations the demarcation was in several places found to be either very defective or altogether wanting, the survey of boundary marks was not taken up by the traverse surveyors. This was subsequently carried out when the plane-table or detail survey came to be made, by which time the settlement *patwaris* had all the marks put up. The demarcation was good, but the pillars erected were intended to answer temporary purposes only, the heavy floods during the rains rendering any attempt at permanent marks useless.

124. To ensure the accuracy of the boundary between British territory and the Bahawalpur State, orders were issued that no part of it should be surveyed unless *zamindars* or other responsible officials on both sides were present, and that in case of disputes the boundary marks, as pointed out by both sides, should be surveyed and shown on the maps: these orders were carried out throughout the whole line. In the case of *mauza* boundaries the presence of the *zamindars* concerned was insisted on.

125. The accuracy of the detail survey was tested by 52 linear miles of *partal* and by the examination *in situ* by Mr. Pemberton, of a certain percentage of field sections, principally those of the younger and less experienced plane-tablers.

126. The only difficulty experienced throughout this survey was the jungle-clearing, but by the very able assistance rendered by the villagers, especially in the tract owned by the Nawab of Rojhan, this was overcome much sooner than might have been expected. The services of Imam Bux Mazari, Nawab of Rojhan, are especially commended, he having very materially forwarded the work by his energetic and zealous assistance in getting the jungle cleared through his estate.

127. The following tabular statement shows the work performed during the field season:—

District and State.	Linear miles of traverses.	Number of traverse stations.	Number of villages.	Number of field sections (skeleton plots).	Detail survey 4-inch scale, square miles.	Remarks.
Dera Ghazi Khan District . .	Main . 138 Minor . 444	1,834	50	43	377	(*a*) This represents the area of the *mauzawar* traverse and the area mapped. The area covered by the four main circuits is 693 square miles.
Bahawalpur State .	Main . 125 Minor . 186	992	24	27	175	
Totals .	893	2,826	74	70	552(*a*)	

128. The whole area (552 square miles) has been fair mapped on 30 sheets for reproduction on the scale of 4 inches = 1 mile. In addition to the above this detachment has, during the recess season, set up and proved the traverse work done in the town of Rewari by two sub-surveyors lent to the Deputy Commissioner of Gurgaon, and has plotted the same on 16 sheets on the scale of 100 feet to the inch. The plotting of 13 villages, on the scale of 24 inches = 1 mile, has also been prepared on 47 sheets for the Settlement Officer of Gujrat.

129. The recess office of the party was inspected by the Surveyor-General at Simla in October 1891. The work in all its branches was found to be highly satisfactory, reflecting credit on Mr. Pemberton's supervision and management.*

FOREST SURVEYS.

CENTRAL PROVINCES.

No. 14 PARTY.

130. This party has remained under the charge of Colonel Wilmer throughout the year, and has been again employed in surveying on the scale of 4 inches to the mile, the first and second class forest reserves in the Hoshangabad and Betul districts; the *malguzári* lands, except where very small detached portions were met with, being left unsurveyed. The party took the field in the last week of December, and carried on field operations till the first week in May, carrying out the following work:—

Personnel.

Colonel J. R. Wilmer, S.C., Deputy Superintendent, 2nd grade, in charge.
Mr. A. Christie, Surveyor, 3rd grade.
" N. C. Gwynne, Surveyor, 3rd grade.
" J. Keating, Assistant Surveyor, 1st grade.
" D. Campbell, Assistant Surveyor, 1st grade.

Sub-surveyors.

Azim Khan, Mohammad Zakaria, Hydar Ali, Gurdutt Singh, Kadir Sharif, and 44 others.

(*a*) Triangulation in the Bori forest reserve and in the second class forests in sheets Nos. 23, 24, 34, and 35. All this work is in advance of the area surveyed in detail, except a portion in sheet No. 24, the computations of which were done in the field and the topography completed.

(*b*) Theodolite traversing for taking up forest boundaries and fire lines, and for supplementing the triangulated frame work for the detail survey in sheets Nos. 23, 24, 25, 26, 34, and 35; also boundary traversing of forest blocks Nos. VI, XI, and XII in sheets Nos. 10 and 11.

(*c*) Detail survey, on the scale of 4-inches to a mile, in the Saonligarh and Bhowergarh forest reserves, and in the second class forest in sheets Nos. 24 and 25, also in the part of Khámapur forest in sheet No. 26, which was left unsurveyed last year

(*d*) Boundary survey of detached forest blocks Nos. I, II, III, IV, V, VI, VIII, IX, and XI in sheets Nos. 10 and 11. This was done with the plane-table, and all principal details were shown that fell within a distance of 5 chains on either side of the boundary, as required by the Forest Department. It was subsequently decided that the survey of these blocks should be undertaken when the party operates in Nimar district.

(*e*) The classification of forest growth and soil of the area surveyed in detail in the year under report.

131. The out-turn of the season's work amounts to the following:—

1. Triangulation of 499 square miles, fixing 665 points (including stations) and 689 heights.
2. Detail survey, on the 4-inch scale, of 461 square miles.
3. Traversing of 600 linear miles.

* With reference to his men Mr. Pemberton reports that all the sub-surveyors, without an exception, have worked most cheerfully and well throughout the season; and none, therefore, need be specially mentioned.

CENTRAL PROVINCES SURVEY.

INDEX TO THE FOREST SURVEYS IN DISTS. HOSHANGABAD & BETUL.

No. 14 PARTY.

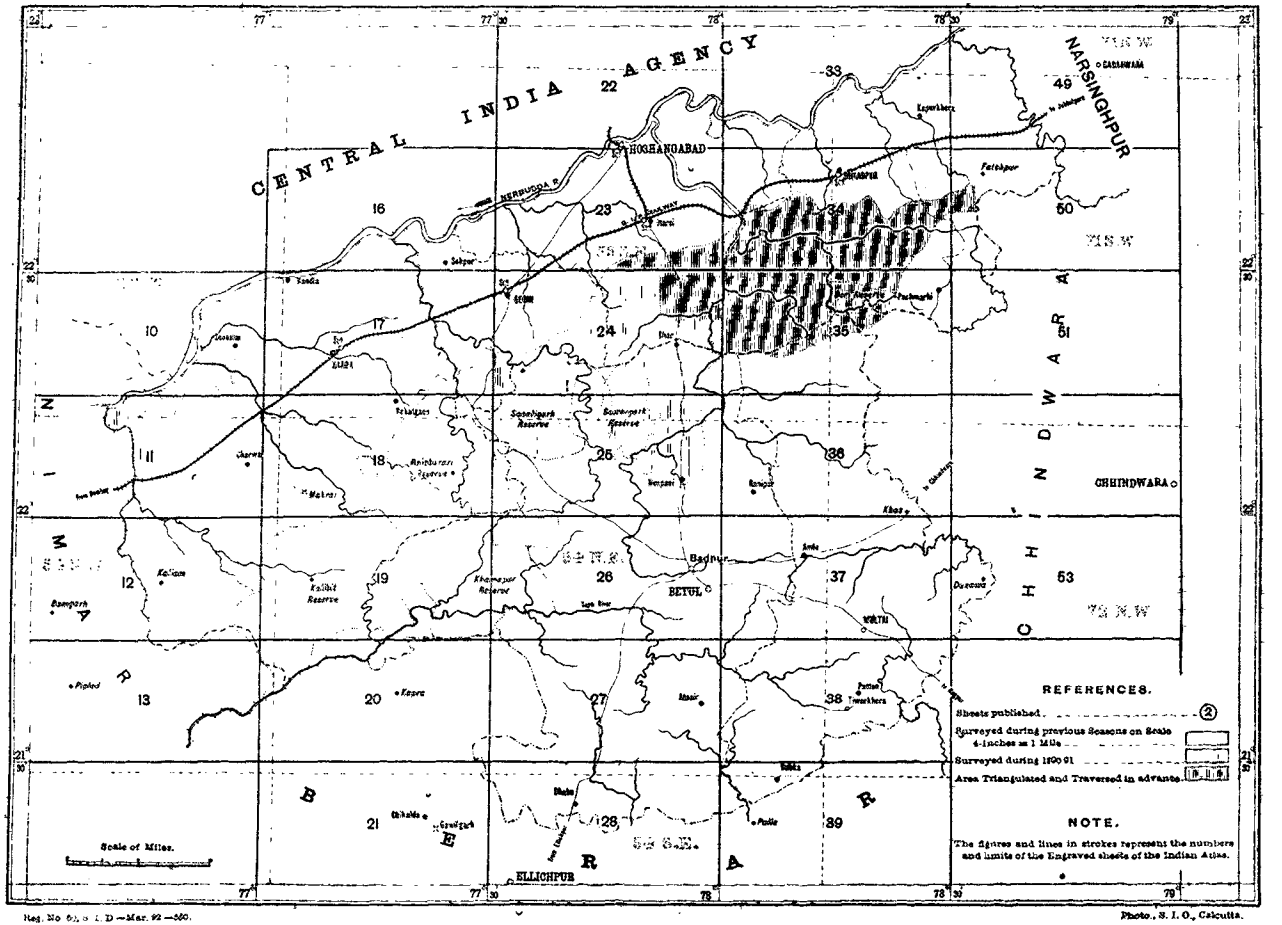

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Photo., S. I. O., Calcutta.

4. The classification of forest growth and soils of the whole area surveyed in detail.

132. The country surveyed in detail was similar to that met with last year in regard to the nature of the ground. It was for the most part very hilly and covered with jungle and high grass which greatly hindered the progress of the work. There were no passes or roads of importance, and the only rivers met with were the Tapti and Moran. The field depôt of the party was changed from Harda to Hoshangabad, as the distance to the scene of operations from the former place became too great for effectual communication and supervision.

133. The health of the party was not quite so good as last year, which was probably due to the peculiarity of the climate and the unhealthiness of the ground. At one time there were six sub-surveyors with their squads incapacitated from sickness, and their work was stopped for about a fortnight. The chief diseases were fever and dysentery, and towards the end of the season there were some severe cases of sunstroke also: there were six deaths in the establishment. The four years' experience which this party has now had in these forests unquestionably establishes the fact that it is impossible to work in them without having some 10 per cent., at least, of the establishment always sick with fever and dysentery, and that the precautions which are taken to prevent illness, *viz.*, the issue of blankets, quinine, and tea, to the establishment and making the men drink filtered water, are indispensably necessary to keep down illness within reasonable limits. Experience has also shown that field operations cannot be commenced much before the first week in January, and, owing to failure of water, must be discontinued by the first week in May: the large rivers certainly have water in them, but it is a remarkable fact that drinking their water or encamping near their banks is a prolific source of fever.

134. The Deputy Conservator of Forests, Mr. W. P. Thomas, has afforded very valuable assistance and advice to Colonel Wilmer when surveying the forest tracts in the Hoshangabad district. Mr. Thomas identified himself with the party, and Colonel Wilmer's thanks are due to him for the personal interest he has taken in the progress of the work, in frequently visiting the several detached camps, and giving the surveyors timely advice and assistance, and encouraging all with whom he has come in contact.

135. The fair mapping of the season's operations has been completed and comprises 25 standard-sized sections on the 4-inch scale in sheets Nos. 24, 25, and 26, which have been drawn for reproduction. The tracings, to illustrate the classification of forests and soils of all the sheets of Hoshangabad and Betul districts specified above, have also been prepared and sent in original to the Forest officers concerned. In addition, office copies of triangulation charts of sheets Nos. 23, 34, and 35 have been completed, and there are no arrears either in the triangulation or traverse computations.

136. Four soldier surveyors joined the party in the beginning of last field season for instruction, three of whom were trained in plane-table survey, and one was instructed in traversing with theodolite and chain: in recess they were practised in map drawing. They will be taught the use of the sextant, boiling point thermometer and artificial horizon before the party again takes the field, and will also be given lessons in route surveying. They will be attached for another year and a half to complete their training in the several branches of surveying.

137. The programme of work for the ensuing field season is as follows:—

(*a*) The triangulation of about 500 square miles in sheets Nos. 8, 9, 14, and 15, in district Nimar;

(*b*) The detail survey of about 500 square miles in Bori forest reserve, and of the second class forest in sheets Nos. 23, 24, 34, and 35;

(*c*) Thedolite traversing over the ground specified in (*a*); and

(*d*) The classification of forest growth and soil of the area to be surveyed in detail.

138. The recess office of the party was inspected by the Deputy Surveyor-General, Trigonometrical Branch, on the 8th September, 1891, who has written as follows:—

"I place on record with much satisfaction my appreciation of the very efficient state in which I find your party to be in all particulars. The general discipline, and system of

division of labour, as well as the standard attained in the drawing of your maps, merit the highest commendations."*

BOMBAY PRESIDENCY.

No. 17 Party.

139. Colonel Pullan on return from privilege leave in December resumed charge of this party and held it up to the 13th of March 1891, when he retired from the service. Mr. Lawson officiated in charge throughout the other periods of the field season, and handed over to Colonel Hutchinson on the 9th of June 1891.

Personnel.

Colonel A. Pullan, S.C., Officiating Deputy Superintendent, 1st grade, in charge from 11th December 1890 to 13th of March 1891.
Colonel H. S. Hutchinson, S.C., Deputy Superintendent, 3rd grade, in charge from 9th June 1891.
Mr. A. M Lawson, Surveyor, 2nd grade, in charge from 1st October to 10th December 1890 and from 14th March to 8th June 1891.
Mr. S. F. Norman, Assistant Surveyor, 1st grade.
Mr. C. A. Norman, Assistant Surveyor, 1st grade.

Sub-Surveyors.

G. R. Bhopatkar, Gopal Vishnu, Gobind Gopal, R. V. Joshi, N. V. Bhopatkar, and 27 others.

140. The party took the field on the 8th of November 1890, closed field work in the commencement of June 1891, and opened office for recess duties at Poona on the 9th idem.

141. The field operations were carried on, as during the previous year, in the Northern and Southern circles of the Presidency, and the party was divided into two sections—Mr. A. M. Lawson supervising the work in the Southern circle and Mr. S. F. Norman that in the Northern circle. Camp No. 1 under Mr. Lawson was employed in completing the survey on the 8-inch scale of the forest reserves in Kalghatgi *taluka*, Dharwar district, and in continuing the survey of Mundgod, Yellapur and a portion of Sirsi *talukas* in North Kanara.

Camp No. 2 under Mr. S. F. Norman was employed in the Northern circle on 4-inch and 8-inch surveys of the forests in the Khed *taluka*, Poona district, Bhiwandi *taluka*, South Thana district, and Sirur, Bhimthadi and Haveli *talukas*, Ahmednagar district.

142. Camp No. 1 accomplished the survey of 300 square miles on the 8-inch scale in the *talukas* mentioned above. In connection with this work an area of 340 square miles of triangulation was executed and 660 linear miles of traverse were run, fixing 5,643 stations. The heights of these stations were obtained approximately, in order to assist in the correct delineation of the ground, and the mathematical results of the whole work proved satisfactory.

Camp No. 2 completed 124 square miles of topography on the 4-inch scale, 93 square miles on the 8-inch, and 22 square miles on the 16-inch scale of *babul* reserves in Bhimthadi, Sirur, and Haveli *talukas*. In connection with these areas, 170 square miles of triangulation were completed, fixing 179 points, and 236 linear miles of traverse were run, fixing 1,223 points, the heights of which were approximately determined.

143. The aggregate out-turn of work for the field season amounts to—

Triangulation	150 square miles.
Traversing	896 linear miles.
Topography	124 square miles on the 4-inch scale. 393 square miles on the 8-inch scale. 22 square miles on the 16-inch scale.

Of the total area triangulated during the season, 85 square miles are in advance of the detail survey in the Southern circle, and 97 square miles in the Northern circle.

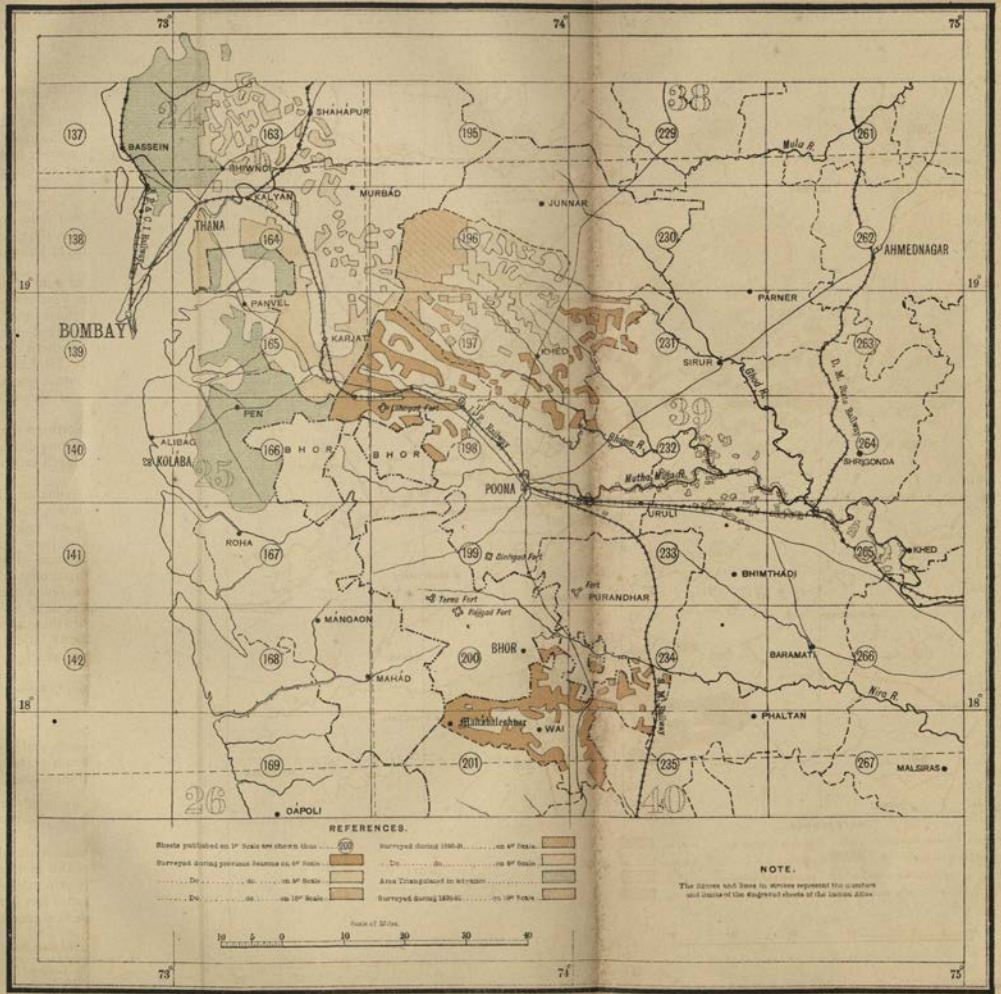
144. The accuracy of the detail survey in both circles was tested either by chain traverses, or (where the nature of the ground did not allow of this method) by examinations *in situ* of each plane table section: that in the Northern circle was tested by 113 linear miles of *partal* lines, and the 16-inch *babul* forest reserve survey was checked by Mr. Lawson, by 37 linear miles of check traverse.

* Colonel Wilmer reports very favourably of Messrs. Christie, Gwynne, Keating, and Campbell, all of whom have worked with zeal and spirit. The following sub-surveyors are also brought to notice, and also the head writer Syed Zille Hasnain:—Sub-surveyors Azim Khan, Hydar Ali, Gurdutt Singh, Kadir Sharif, Karimdad Khan, Ram Singh, Mahadeo Daji, Sutto Charan Ghosal, Surjan Singh, Abdul Haq, Abbas Ali, Sita Ram, Mohammad Zakaria, Sahaidin, and computer Mohindro Nath Bose.

BOMBAY SURVEY.

INDEX TO THE FOREST SURVEYS IN PORTION OF THE NORTHERN CIRCLE.

No. 17 PARTY.



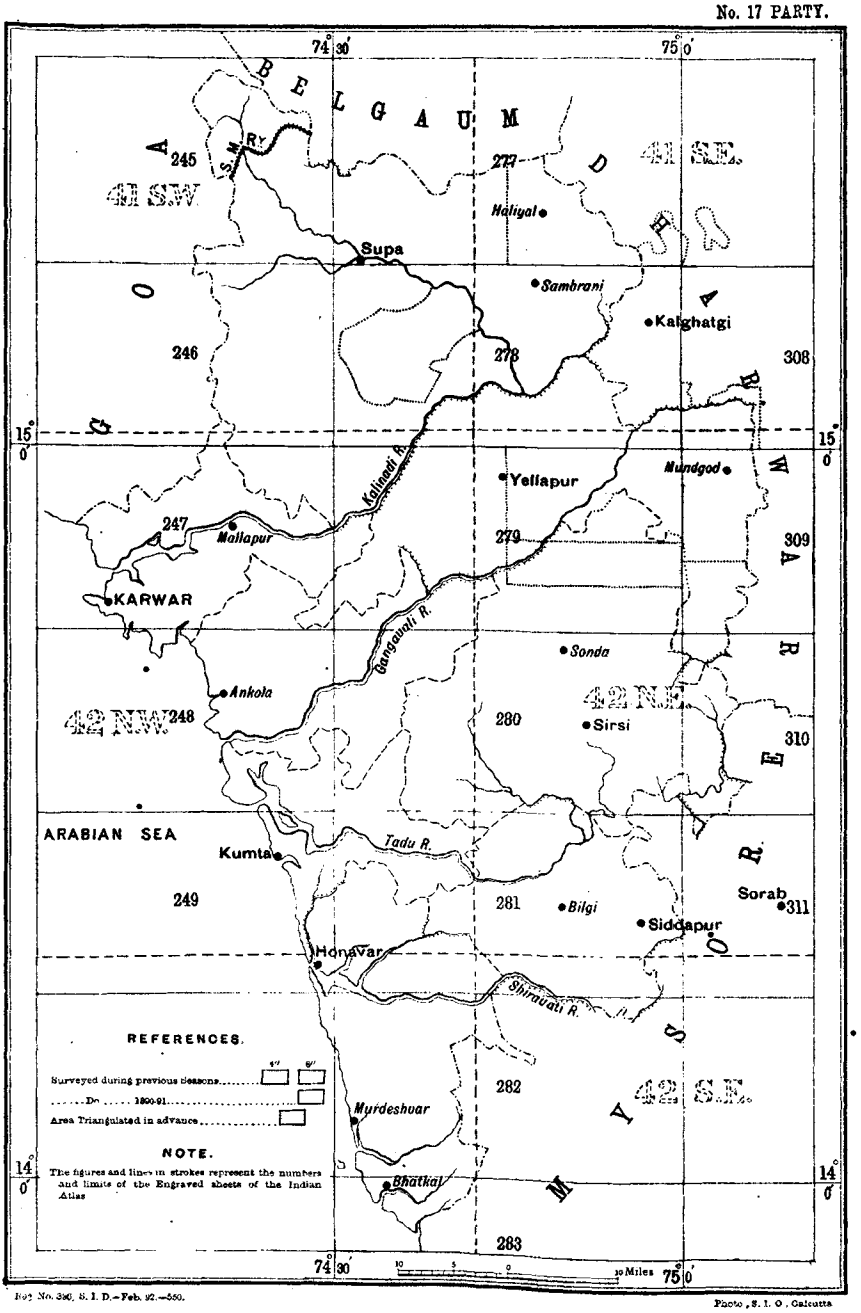
Reg. No. 401, S. I. D.—Feb. 91.—550.

Photo., S. I. O., Calcutta.

BOMBAY SURVEY.

INDEX TO THE FOREST SURVEYS IN THE SOUTHERN CIRCLE (N. KANARA).

No. 17 PARTY.



Reg. No. 396, S. I. D.—Feb. 92.—550.

Photo., S. I. O., Calcutta

145. The cost rate per square mile of the 8-inch survey, including cost of triangulation and traversing, amounts to R112 in the Southern, and R167 in the Northern circle; the former rate is very low, which is due to the ground being favourable and easy for survey, while the latter is not high for 8-inch work, the enhancement being due to the scattered nature of the work, and intricacies of the ground met with in the Northern circle. The 4-inch work cost R112 and the 16-inch R193 per square mile.

146. During the recess the fair mapping of the detail survey executed during the field season was completed, and in addition certain arrears of mapping of previous seasons' work in districts Nassik, Poona, and Thana. The computations of the triangulation and traversing were also brought up to date.

147. The health of the establishment employed in the Northern circle remained fair throughout the season. In the section working in the Kanara jungles fever and dysentery were very prevalent, as can only be expected, and during the earlier part of the field season, survey operations almost came to a standstill owing to the number of men in the native establishment incapacitated by sickness.

148. The following is the programme to be carried out during the coming field season as approved by the local authorities:—

In the Northern circle, the 16-inch survey of the *babul* reserves in the Bhima valley will be continued: the 8-inch survey will be carried on in Salsette and Bhiwandi *talukas*, Thana district; in Haveli *taluka* of the Poona district and Jaoli Boleshwar, and in parts of the Akola and Sangamner *talukas*, Ahmednagar district. In the Southern circle, the 8-inch detail forest survey is to be carried on in the Pen and Panvel *talukas*, Kolaba district, and the 4-inch survey is to be continued in the Sirsi *taluka* of the Kanara district.

149. The recess office of the party at Poona was inspected during September 1891 by the Surveyor-General. The field sections were scrutinized and gave evidence that the survey had been executed with care and accuracy. Of these, sixteen sections were suitable for reproduction by photography, which saved the labour of re-drawing fair maps thereof. All the professional records were found to be systematically kept and well up to date, and the general arrangements for the division of work excellent. The standard maps were well drawn, and no arrears of any description existed. The Officiating Survey and Settlement Commissioner and the Conservator of Forests, Northern circle, were consulted regarding the general utility of the work for its special requirements, and they expressed themselves completely satisfied with the maps that were being rendered for forest purposes.*

MADRAS PRESIDENCY.

No. 19 Party.

150. The season for field operations in this party differs from that of other survey parties, owing to the local peculiarities of the climate, and commences about two months earlier than the ordinary date. The recess office was closed in the last week of August 1890, and the different sections immediately started for the various localities in which field operations were to be carried on, *viz.*, No. I section, under Mr. R. Todd, to the Coimbatore district, to commence the preliminary operations of triangulation and traversing to which the work of this section was confined; No. II section, under Mr. Hamer, to continue the topography of the reserved forests in the Madura district, together with any additional triangulation

Personnel.

Lieutenant-Colonel J. R. McCullagh, R.E., Deputy Superintendent, 2nd grade, in charge.
Mr. C. F. Hamer, Surveyor, 3rd grade.
„ H. Todd, „ „ „
„ R. Todd, Assistant Surveyor, 1st grade.
„ T. J. J. Mills, Assistant Surveyor, 2nd grade.

Sub-Surveyors.

T. Raghava Ayengar, V. Tiruvenkatsami, Lachman, D. Jadow, Balaji Dhondiba, Govindraju Mudaliar, Anantarao Dhondiba, Govind-Mukund, and 12 others.

* Colonel Hutchinson reports favourably on the services of the three European Assistants, Messrs. Lawson, S. F. Norman, and C. A. Norman, especially of the first named who held charge of the party during a large part of the field season and by whose energy and perseverance the successful results of the field operations has been mainly secured. The following sub-surveyors receive special mention:—G. R. Bhopatkar, Gopal Vishnu, Gobind Gopal, R. V. Joshi, N. V. Bhopatkar, Ramrao Sadao, and N. R. Patwardhan.

and traversing that might be needed; No. III section, under Mr. H. Todd, to continue the detail survey of the reserved forests in the Tinnevelly district.

151. The field operations were commenced early in September 1890, and continued until the beginning of March 1891, when the party returned to recess quarters in Bangalore.

152. In Coimbatore, the triangulation was carried southwards over a considerable portion of the Anaimalai hills, and also over the western part of the district; it embraces an area of 700 square miles, obtained by observations at 95 stations, from which 333 points were fixed. In Madura, the existing triangulation was extended over an area of 250 square miles by observations at 23 stations, whereby 98 points were fixed and their heights obtained. In Tinnevelly, it was only necessary to supplement the triangulation which had previously been done for a survey on the 1-inch scale, and additional points were fixed to give a suitable basis for the 4-inch survey.

153. The traversing carried out during the season amounts to 266 linear miles of boundary survey. The small amount of this class of work, compared with the area topographically surveyed, is due to the circumstance that the exterior boundaries of the reserved forests had, in some instances, been completely, and in others partially, surveyed by the Madras Survey Department, and the data were obtained therefrom and utilised; the labour and expense of fresh boundary traverses was thereby saved, while at the same time the subsurveyors who would have been engaged on this duty became available for the detail survey.

154. The area of topography executed amounts to 465 square miles on the 4-inch scale, which is a very considerable increase on that previously obtained, this out-turn being more than that of the two previous years put together. This result is very satisfactory, for the country operated in is as difficult as that met with before, and the work was considerably retarded by the abnormal rainfall in February and the amount of sickness which prevailed among the native establishment, the casualties from various causes amounting to 55 during the season.

155. The European assistants exercised a constant supervision over the men in their respective sections, and were held directly responsible for the accuracy of the work turned out: in addition to this, the Deputy Superintendent visited the different sections from time to time and examined the work of the various members of the party, as far as the distances to be travelled over, and the difficulties of moving from place to place permitted. The work, wherever examined, was found to be generally accurate and carefully done.

156. The country surveyed this season differs but little from that described in previous years. In Tinnevelly, the same high and precipitous mountains were met with, in some places densely covered with impenetrable forest growth. Similar difficulties were experienced in the Anaimalai hills and in Madura, though the general level of the country therein was not at so great an altitude above the sea, yet the hills were sufficiently high and intricate to entail considerable labour in moving about amongst them. With but few exceptions, and to a very limited extent, the reserved forests were situated in the most out-of-the-way and inaccessible tracts of country, which rendered the arrangements for supplies, labour, and carriage peculiarly difficult.

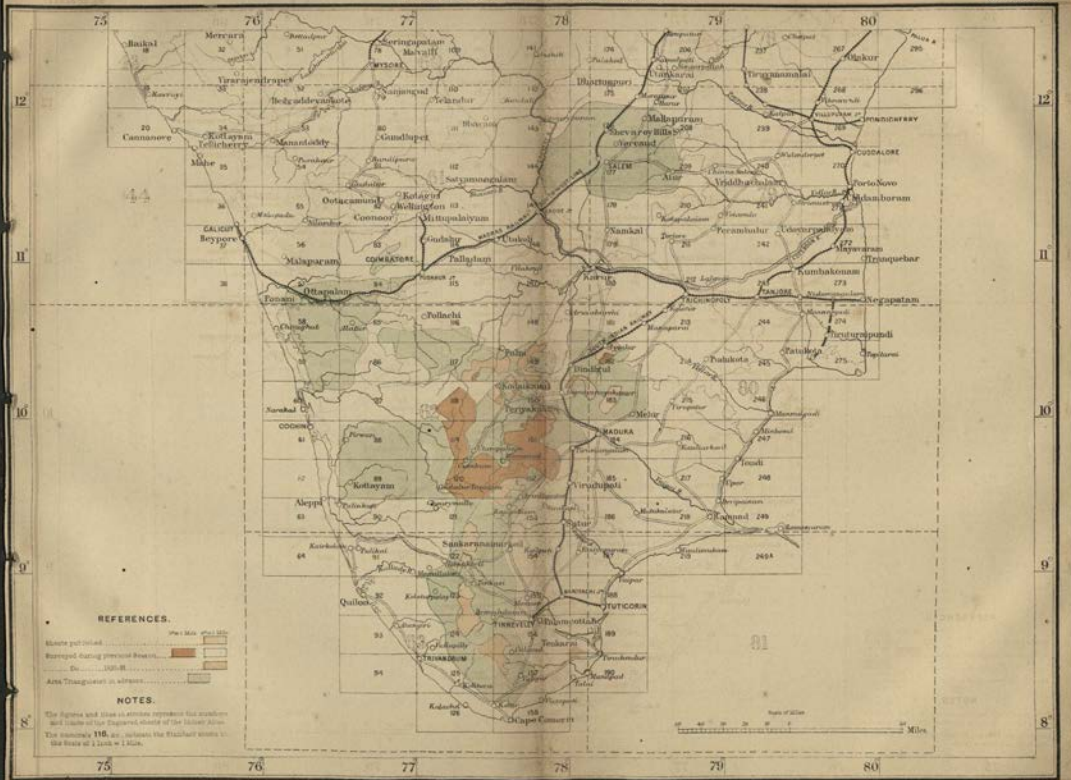
157. Over a considerable extent of the forests in Tinnevelly met with this year, the forest growth was found to be so dense as to be practically impenetrable, and an accurate survey showing all the details of the ground thereof could only have been effected by going to an enormous expense, a course which was not considered justifiable. After reference to the local forest authorities it was decided to get as good a reconnaissance of the tract as possible without incurring much time or expense over it. By cutting tracks and clearing some of the hill tops, a fair general view of this difficult country was obtained, and the main features thereof have been thus fairly delineated; but as the accuracy of the details therein cannot compare with that of the other tracts surveyed, a note has been inserted on the map stating that the survey of this portion is approximate only.

158. During the recess the various computations have been brought up to date, the fair mapping has been completed of eight reserved forests, and part of a ninth, in Madura, and of three large reserves (with the exception of a few square miles) in Tinnevelly—the whole being included in thirty sheets. In

MADRAS SURVEY.

INDEX TO THE SURVEY OPERATIONS IN MADRAS.

No. 19 PART.



addition to the ordinary mapping, and as demanded in previous years, a good deal of time and labour was also expended in the preparation of tracings of the field sheets, for the immediate use of the officers of the Forest Department.

159. The annual out-turn of work in this party has been much below, and the cost rate consequently much in excess of, the original estimates made before the survey of the forests was commenced. This has been chiefly due to causes beyond the control of the Survey Department, *viz.*, the physical difficulties of the country, its unhealthiness, the high rates of pay prevalent, and the difficulty in obtaining suitable recruits to increase the staff of native surveyors so as to obtain a proper proportion of the working to the supervising agency, on which the cost of survey work mainly depends. Such difficulties were not foreseen when the original estimate of cost was made, and from the experience that has now been gained it is evident that the cost was under-estimated. There has, however, been a steady and very decided decrease in the cost of the work since it was first commenced, as the following statement will show:—

		R
In 1888-89,	cost rate per square mile .	162
„ 1889-90,	ditto ditto . .	149
„ 1890-91,	ditto ditto . .	112

These rates are for the final survey, including the cost of triangulation and traversing, and when the party obtains its full complement of native surveyors, it is hoped that the rate will be still further reduced; but owing to the difficulties to be encountered, it is doubtful if a lower rate than R100 per square mile will be possible.

160. In April 1891, the Surveyor-General proceeded to Madras to inspect Colonel McCullagh's party, and to confer with the local authorities regarding its cost and future working. A conference was held on 25th April with the Forest member of the Board of Revenue and the Conservator of Forests, when the causes for the excess cost over the original estimate were fully explained, and the necessity shown for increasing the grant of annual expenditure which had been fixed at R60,000, and which was found insufficient to maintain a properly equipped party with the desirable proportion between the number of Native surveyors and the European staff. This was accepted, and the Board agreed to urge the Madras Government to sanction a grant of R75,000, which has been subsequently allowed. It was also explained that one of the causes effecting the high cost of the survey was due to the survey sections having to re-visit the same localities several times owing to the separate and contiguous blocks of forests requiring to be surveyed not being all settled, and finally notified as reserved forests before the surveyors come on the ground. The Forest Member and Conservator promised to take special measures to expedite the settlement of all the forest blocks in the districts in which survey is being undertaken, so that the survey of adjacent blocks may be dealt with at one time, a measure which is obviously necessary for economical working.

161. The recess office of the party was inspected at Bangalore, and the Surveyor-General was well satisfied with all that he saw and with the arrangements that Colonel McCullagh had made to cope with the exceptional difficulties he had to contend with. To his energy and good management of the means at his disposal the improved results of the labours of the party are attributable. The professional records were found to be systematically arranged, and the field maps showed evidence that the survey had been executed with much care, and with as great regard to accuracy as the nature of the country permitted, without undue expenditure of time and money, and as far as the objects of the survey required.

162. The programme for the ensuing season, which has been approved by the local authorities, comprises the completion of the detail survey of the forests in the Tinnevelly district, where only a small area remains; the continuation of topographical operations in the Madura district, and the commencement of the same in the Coimbatore district, in which the triangulation will also be further extended.*

* Colonel McCullagh reports very favourably of the services rendered by the European assistants, all of whom have done well, and he specially selects Messrs. Hamer and H. Todd, on whom the greater responsibility rested. The sub-surveyors generally are reported to have done very well; special mention being made of the work of Lachman Jadow, and Govind Mukund, while that of Raghava Ayengar, V. Teruvenkatsami Balaji Dhondiba, and Ramasami Naidu is commended.

LOWER BURMA.

No. 20 Party.

163. Colonel Beavan held charge of this party throughout the year, with the exception of the period from 20th of September to 15th of November 1890, during which he was absent on privilege leave, when Mr. Barker officiated in charge.

Personnel.

Colonel R. Beavan, S. C., Officiating Deputy Superintendent, 2nd grade in charge.
Mr. W. A. Wilson, Surveyor, 2nd grade, from 18th November 1890.
„ J. A. Barker, Surveyor, 4th grade.
„ A. F. Ewing, Assistant Surveyor, 1st grade.
„ H. A. Charrier, Assistant Surveyor, 2nd grade.

Sub-Surveyors.

Venkat Swamy, Abdulla Khan, Sharf ud-Din, Girdhari Lall, Amjad Ali, Moung Kyow Nyein, Moung Hpo Nyein, and 16 others.

164. The party has been engaged in carrying on the survey of the forests in districts Prome and Toungoo, on the scale of 4 inches to the mile: and of the intervening tracts on the scale of 2 inches to the mile, the reserved forests being surveyed on the larger scale to meet the requirements of the Forest Department.

165. The first detachment under Mr. Ewing left Rangoon on the 25th of November, and proceeded *viâ* Prome to Pakkaung, to undertake the 2-inch survey required to complete sheet No. 226: the remainder of the party was detained for some time at Rangoon, owing to an outbreak of cholera among the *khalâsis* during the voyage from Calcutta. It eventually left Rangoon on the 23rd of December, and proceeded *viâ* Toungoo to start work in the Kabaung forest, on the 4-inch scale. The delay, fortunately, did not very materially affect the out-turn, as it is not safe to enter the forests in Toungoo earlier than the end of December, owing to their unhealthiness.

166. The head-quarters camp was established at Toungoo as in the previous season, and the hospital was stationed at Thabetkwe, 15 miles to the west, where all ordinary cases were treated, the more serious ones being sent in to the Toungoo hospital.

167. The 2-inch work in the Prome district was completed by the 20th of March, after which Mr. Ewing with his detachment proceeded across the Yoma range, and joined the rest of the party in the Kabaung valley. The upper portion of this valley having proved, during the previous field season, to be extremely unhealthy, the survey of it was postponed until the latter part of the season and with good results, as the amount of sickness was not nearly so great as had been the case the year before. Still there were a good many cases of fever and dysentery, which must necessarily be the case in so malarious a tract of country. The party lost by death, during the field season, one sub-surveyor, two *chuprasis*, and seven *khalâsis*, not including five men, who died of cholera on boardship.

168. Field work was continued until the 20th of May 1891, after which the party returned to Rangoon for the recess. The result of the season's work shows an out-turn of 167 square miles of topography on the 4-inch scale, and 204 square miles on the 2-inch scale. In addition, there are about 250 square miles of traverse work, the total length of chained traverse lines being 340 miles, all through dense jungle. Some triangulation was also carried out with a view to fixing points on which to connect the traverses, and prevent any accumulation of error.

169. Regarding the country Colonel Beavan reports:—

"It would be difficult to find anywhere else a tract of country which offers so few facilities for an accurate survey. The hill ranges rise to a height of 1,400 to 1,500 feet, but there are no very prominent peaks, and they are all covered from base to summit with a dense forest growth. The detail surveyor has to rely entirely upon traverse and chain measurement, and to cut his way through the bamboo jungle, while the traverse surveyor has to contend against the drawbacks of very short lines and broken ground, most unsuitable for accurate chaining. The country surveyed on the 2-inch scale near Pakkaung is of a less formidable character; it is not so hilly, and the forest is more open, being broken up by occasional patches of cultivation."

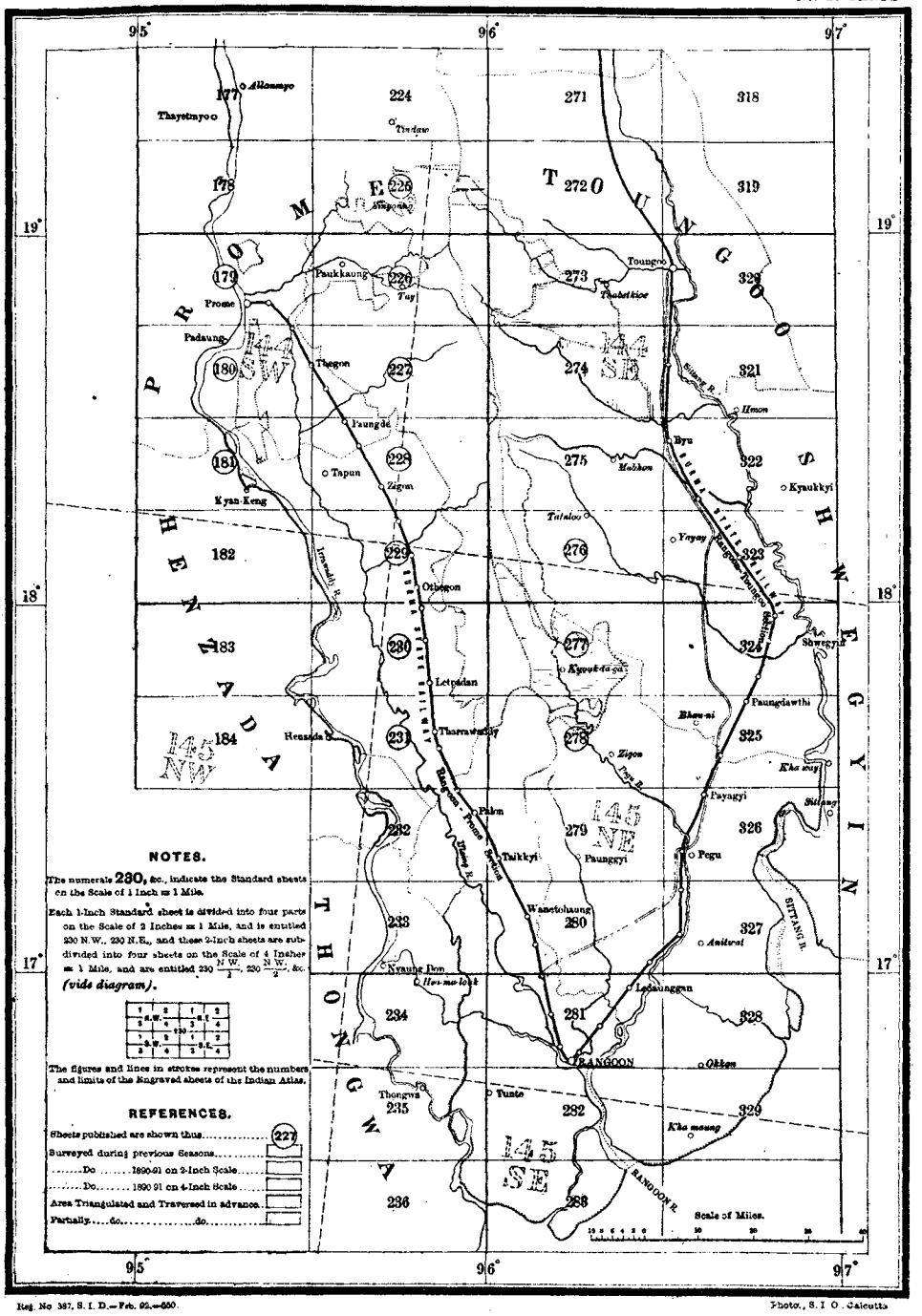
170. The triangulation and traverse work, after computation, proved satisfactory. The detail survey was carefully tested by means of *partal* lines, of which 115 linear miles were run through the different field sections: the work generally was found to be very accurate.

171. During the recess, the computations have all been brought up to date. Some of the old work had to be revised and the corrections re-distributed, in

BURMA SURVEY.

INDEX TO THE FOREST SURVEY IN LOWER BURMA.

No. 20 PARTY.



NOTES.

The numerals **230**, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.

Each 1-Inch Standard sheet is divided into four parts on the Scale of 2 Inches = 1 Mile, and is entitled 230 N.W., 230 N.E., and these 2-Inch sheets are sub-divided into four sheets on the Scale of 4 Inches = 1 Mile, and are entitled 230 $\frac{N.W.}{1}$, 230 $\frac{N.W.}{2}$, &c. *(vide diagram).*

The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.

REFERENCES.

Sheets published are shown thus..... (227)

Surveyed during previous Seasons.....

.....Do .....1890-91 on 2-Inch Scale.....

.....Do.....1890-91 on 4-Inch Scale.....

Area Triangulated and Traversed in advance.....

Partially.....do.....do.....

Reg. No 387, S. I. D.—Feb. 92.—650.

Photo., S. I. O., Calcutta.

order to make the traverse co-ordinates conform to data derived from triangulation, but the alterations are not sufficient to distort the topography to any sensible extent. Six standard sheets, on the 4-inch scale, have been drawn for reproduction, and four sections of sheet No. 226 have been drawn on the 2-inch scale for reduction to one inch. The compilation of General Report volumes has been proceeded with systematically. The junior sub-surveyors and apprentices have been steadily practised in map-drawing and topography.

172. The programme for the ensuing field season provides for the detail survey of the remaining portion of the Kabaung reserve, the whole of the Bhongdong reserve, the Pyu reserve, and the portions intervening between these reserved forests. This will complete (as far as forest surveys are concerned) standard sheets Nos. 273 and 274. The advance traverse and triangulation will be extended northwards in the east and west Swa reserves, as far north as 19° 15′ or beyond this line, if time allows.

173. On the 27th April, the Deputy Surveyor-General, Revenue Branch, inspected the field office and one of the traverse camps of the party; more than this it was impossible to do, as the rest of the party were engaged on the field work at considerable distances from Toungoo in a very inaccessible country. The traverse camp was in charge of Mr. W. A. Wilson, who was supervising it under great difficulties in consequence of the fever from which he constantly suffered. The Deputy Surveyor-General was thoroughly satisfied with all that he saw, and considers, so far as he could judge from a distant view of the country where the field operations were being carried on, that Colonel Beavan's remarks as to the difficulty of effecting an accurate survey are fully justified.*

CADASTRAL SURVEYS.

CHITTAGONG AND TIPPERAH DISTRICTS, BENGAL PRESIDENCY.

NO. 2 PARTY.

174. This party, of the strength shown in the margin, continued its operations in the district of Chittagong, and finished the survey of *pargana* Serail in Tipperah. The record-writing of that portion of the island of Dakhin Shahbazpur, which it had been found impossible to complete last season, was handed over to the settlement department; tracings having been made of the original sheets, they were sent to the settlement officer.

Personnel.

Mr. F. Grant, Officiating Deputy Superintendent, 4th grade, in charge up to 10th July 1891.

Chittagong Section.

Mr. W. J. O'Sullivan, Surveyor, 3rd grade, in temporary charge of party, from 11th July 1891.
" J. McHatton, Surveyor, 4th grade.
" C. G. Lee, Assistant Surveyor, 2nd grade.
Babu Sarat Chandra Sen, Assistant Surveyor, 3rd grade.
42 sub-surveyors, computers, etc.
97 field surveyors, and others.

Serail Section.

Mr. P. C. H. Smart, Assistant Surveyor, 1st grade.
3 sub-surveyors.
27 field surveyors and others.

175. The regular field operations did not commence until the 10th December, the delay being caused by the necessity of completing as many villages as possible for the settlement officers before moving into the field, and from the difficulty experienced in preparing the records. In Chittagong, however, from the early part of November, revisions of the previous season's record-writing, as well as the new record-writing of what had been surveyed, were carried on.

Survey of the Chittagong District.

176. During the previous season local *amins* had been employed on writing the *khasras*, but the supervising staff were Hindustanis, who, through a want of sufficient knowledge of the language, were unable to exercise a proper check on the work. In consequence of this, numerous mistakes crept into the records, and it was decided at a conference with the Director of Land Records that the writing of the *khasras* should be handed over to the settlement department, and on the 1st January this portion of the work was accordingly transferred to the

* Colonel Beavan reports favourably on the work performed by all the European assistants, giving special mention to Mr. Ewing. The Native assistants, with three exceptions, are well reported on.

settlement officer. The *amin*, being thus freed from the labour of making out these intricate returns, would have all the more time to carry out the survey proper. It was also decided to strengthen the establishment of *amins*, so as to enable the party to complete by the end of March 1892 the 650 square miles of cultivation and the 500 square miles of hill tracts which it was then supposed formed all that was left for survey. Since then it has been reported that there will be considerably more ground to be included in the survey, in which case it is doubtful whether the party may not have to remain another season in the district: during the season under report the native staff was increased by nearly 50 per cent.

177. The country presented many difficulties to the traverse surveyors, more especially to the new and inexperienced hands, of whom there were a considerable number. The dense undergrowth intertwined with creepers, the big swamps covered with elephant grass, the intermixture of the cultivation with the hills and the distances the men had to go to and from their camps, all combined to make the survey slow and laborious. In the hilly tracts there were many tea gardens dotted about and the demarcation and mapping of these was difficult. But the worst task of all was the laying down of the boundary of the hill tracts as well as that along the watershed between *thanas* Hathazari and Fatikchari on the one side and Mirkiserai and Kumira on the other. These boundaries are situated far from any villages and run over steep hills, through valleys thickly covered with jungle, and across broad swamps.

178. The actual amount of traverse surveying completed is shown in the following table:—

District.	Number of village circuits.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Chittagong	450	747	22,427	806

At all the trijunctions of villages and their adjacent stations, stone prisms or blocks of ballast were embedded; the other intermediate traverse stations were marked with baked clay cylinders. Three trigonometrical stations were connected with the work to check the chaining, whilst 342 azimuths were observed to check the angular work. It was hoped that the traverse survey of the district would have been completed this year; but, owing to the difficulties already described and to the early setting in of the rains, an area of about 200 square miles was still untraversed, when the sub-surveyors were forced to return to recess quarters.

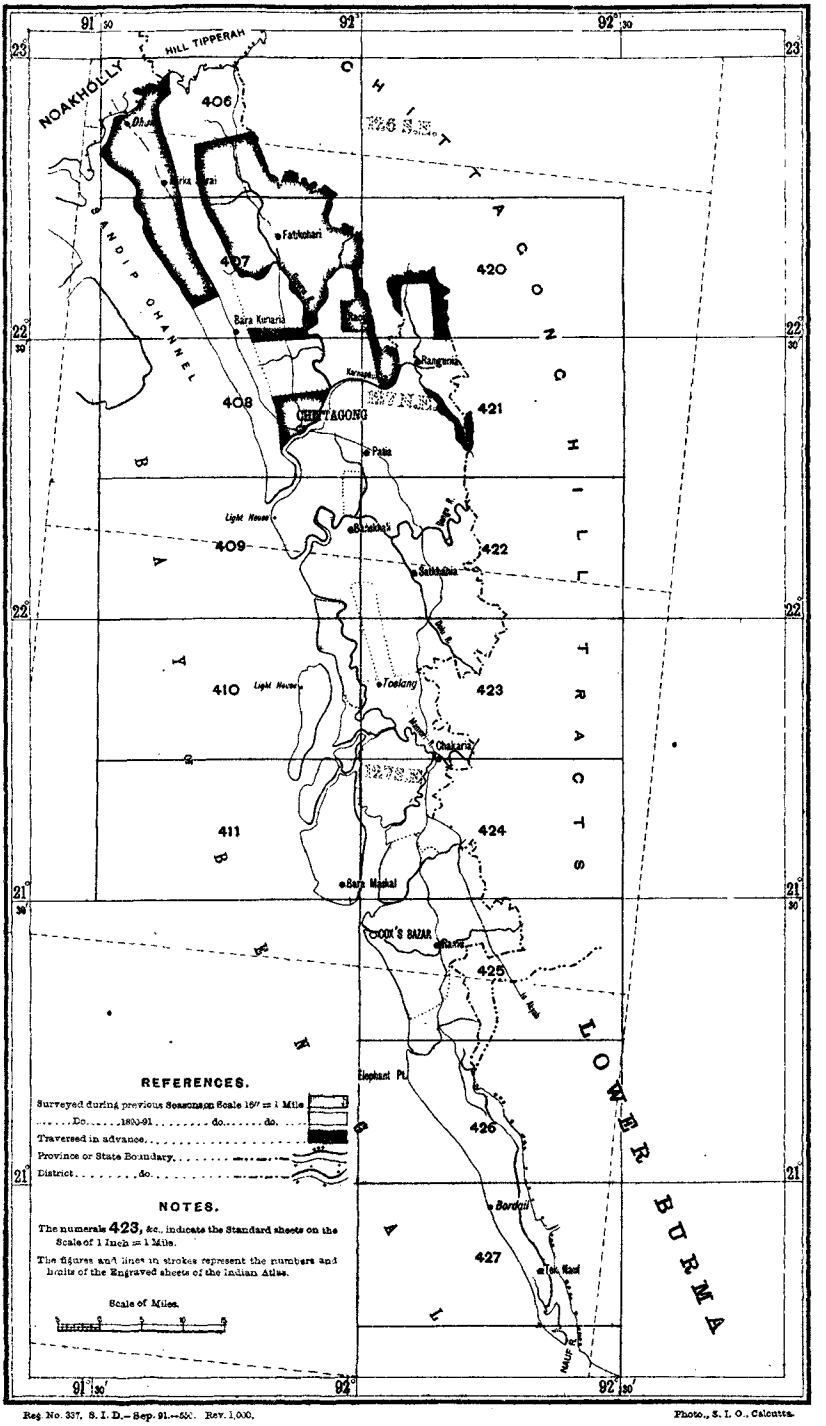
179. The detail survey commenced about the 15th December 1890 with only 80 *amins* at first; this number was increased during the first six weeks to 93, and subsequently in February 1891 to 140. In May, the numbers were greatly reduced, as the unusually early and very heavy rains flooded the country and put an end to field work. In *thana* Patia, where work was commenced, the fields were fairly large, averaging about ·25 of an acre, and consequently good progress was made; but as the work advanced towards the hills to the east, the fields became very small indeed, so much so that the average size of the fields throughout the entire work proved to be only ·13 of an acre. The extraordinary amount of minute detail in the village sites necessitated the special employment of some of the best *amins* on this survey, no ordinary *amin* being able to deal with such intricate work. These sites varied from small towns of half a mile square to small hamlets of 5 or 6 homesteads. Each homestead has its own little plot of vegetable garden or betel-nut plantation, and frequently a tank marked off with a trench and bamboo fence, while to secure privacy the whole is surrounded by a thick hedge of cane or bamboo. A mass of such residences all close together, embedded in trees as they are, appears like a wood instead of a town or village site, not even the roof of a single building being visible from outside.

180. The cost rate per acre on traverse and cadastral survey is 6 annas 6 pies, which is somewhat high, owing mainly to the causes specified in the previous paragraph, together with the fact that wages in Chittagong are very high, amounting to ₹8 per mensem for each chainman.

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. CHITTAGONG.

No. 2 PARTY.



Reg. No. 337, S. I. D.—Sep. 91.—500. Rev. 1,000.

Photo., S. I. O., Calcutta.

181. The average daily progress of an *amin* under these circumstances was only about 14 acres of cultivation or 5 acres of village sites. In addition to the 16-inch field-to-field survey, a tract of country of 82 square miles in *thana* Ramoo was surveyed on the 2-inch scale; another of 65 square miles between *thana* Banskati and Satkania; and a third tract of 55 square miles was topographically surveyed in skeleton on the 16-inch scale. The total out-turn of detail survey was as follows:—

District.	Number of villages.	Number of fields.	Area in square miles.		
			Cadastral, 16-inch scale.	Topographical Skeleton, 16-inch scale.	Topographical 2-inch scale.
Chittagong	505	16,50,875	349	120	82

182. With regard to the attitude of the inhabitants towards the surveyors, Mr. Grant reports that they did not interest themselves much about the survey of the fields, but left it to the *chaukidars* to point out the boundaries to the *amin*; they were however very civil to the *amin*, and attended him closely when writing the records. Many errors and omissions of village and other undefined boundaries, which should never have occurred had they attended on the survey *amin*, were readily pointed out; in these cases the field surveyor was the sufferer, as he had to return and revise the boundaries, which, as he worked by contract, was a loss to him.

183. On the night of the 21st April the first heavy shower of rain fell, and, contrary to custom, the wet weather continued until the 20th May, when the fields were flooded and out-of-door work became impossible. It then became evident that it was useless expense to keep on the costly field establishment, and by the 4th June the detail surveyors were discharged. The traverse camp returned to recess quarters on the 12th June, leaving a few parties to complete the work actually in hand. This early setting in of the rains considerably reduced the season's out-turn.

184. During the recess the following maps and records have been supplied to the settlement officer:—

District.	Prepared for record-writing.		Drawing completed.			Tracings completed.		Areas of fields completed.	
	Villages.	Area in square miles.	Villages.	Sheets.	*Khasra* numbers.	Villages.	*Khasra* numbers.	Villages.	*Khasra* numbers.
Chittagong .	418	619	268	516	6,16,528	288	6,76,230	228	4,73,495

185. During the field season it was found very difficult to keep pace with the demands of the settlement officer for tracings and areas, as it was not possible to entertain a large staff of draftsmen and estimaters to take up and finish each batch of sheets as it was received from the settlement office, as this would have involved most of the men remaining idle afterwards till another batch of sheets was received. As the men were working by contract, it would not have paid them to do this, and they would have deserted had they been forced to do so. In recess, when a sufficient quantity of work had accumulated, the establishment was increased, and during the coming field season it is believed that, acting on the experience of the last season, more effectual measures will be taken to prevent delays. It is satisfactory to be able to add that, within seven weeks after the above statement of work submitted to the settlement officer was made out, the whole of the records due to that officer had been sent in and the cadastral party took the field unencumbered with any arrears. To the energy of Mr. O'Sullivan, who held charge temporarily from 11th July, this is due.

186. The head-quarters office of the party was inspected by the Deputy Surveyor-General on the 15th and 16th of February 1891 at Chittagong. The record-writing was at this time being done by the settlement department, the survey party being only responsible for the cadastral work; the Deputy Surveyor-General also accompanied His Honor the Lieutenant-Governor when inspecting the record-writing in the field under Mr. Slack, the Settlement Officer. All the records, the computations, etc., etc., in the office were carefully inspected and approved of.

Survey of the Serail Pargana, Tipperah District.

187. A detachment under the immediate supervision of Mr. P. C. H. Smart was sent to Serail to complete the survey and the record-writing which remained incomplete from last season. Twenty *amins* were employed on the field survey and on the *khanapuri*, of whom some were sent to Chittagong after a month, and in six weeks from the commencement of field work the number was reduced to ten. As these men finished their work, they were also drafted away to Chittagong, until by the end of March they had all joined the main party.

188. The field was the unit of survey; but the holding was the unit of the record-writing, and where more fields than one belonging to the same *rayat*, and in all respects similar, were found clubbed together, they were treated as one, and one number was given to them. The *amins*, both for survey and record-writing, were Hindustanis, it having been found that Bengalis were unable to make sufficiently rapid progress; moreover, with the exception of two men, none of those who had worked in Serail last year applied for employment this season; local men were engaged to assist the Hindustanis in writing in Bengali. Each *amin* surveyed on an average 45 acres a day, earning an average of ₹32 a month; in record-writing, their average out-turn was 99 fields, or about 74 acres a day, by which they earned ₹45 a month. The inking-in of field sheets and the tracings were done by Hindustanis. Areas were extracted by Hindustanis and Bengalis; these areas, which were as usual taken out in the first place in acres and decimals, had to be converted into two different local standards of measure, one for *khalsa* and another for tenure-held lands; the separation of these different measurements, for the purpose of totalling, was perplexing and tedious.

189. The detachment took the field on the 13th December and retired to recess quarters on the 27th April. The actual out-turn of work completed is shown in the following table:—

District.	Cadastral Survey.			Record-writing.		
	Number of villages.	Number of fields.	Area in square miles.	Number of villages.	Number of fields.	Area in square miles.
Tipperah . .	16 in part	16,089	23·11	44	80,335	77·18

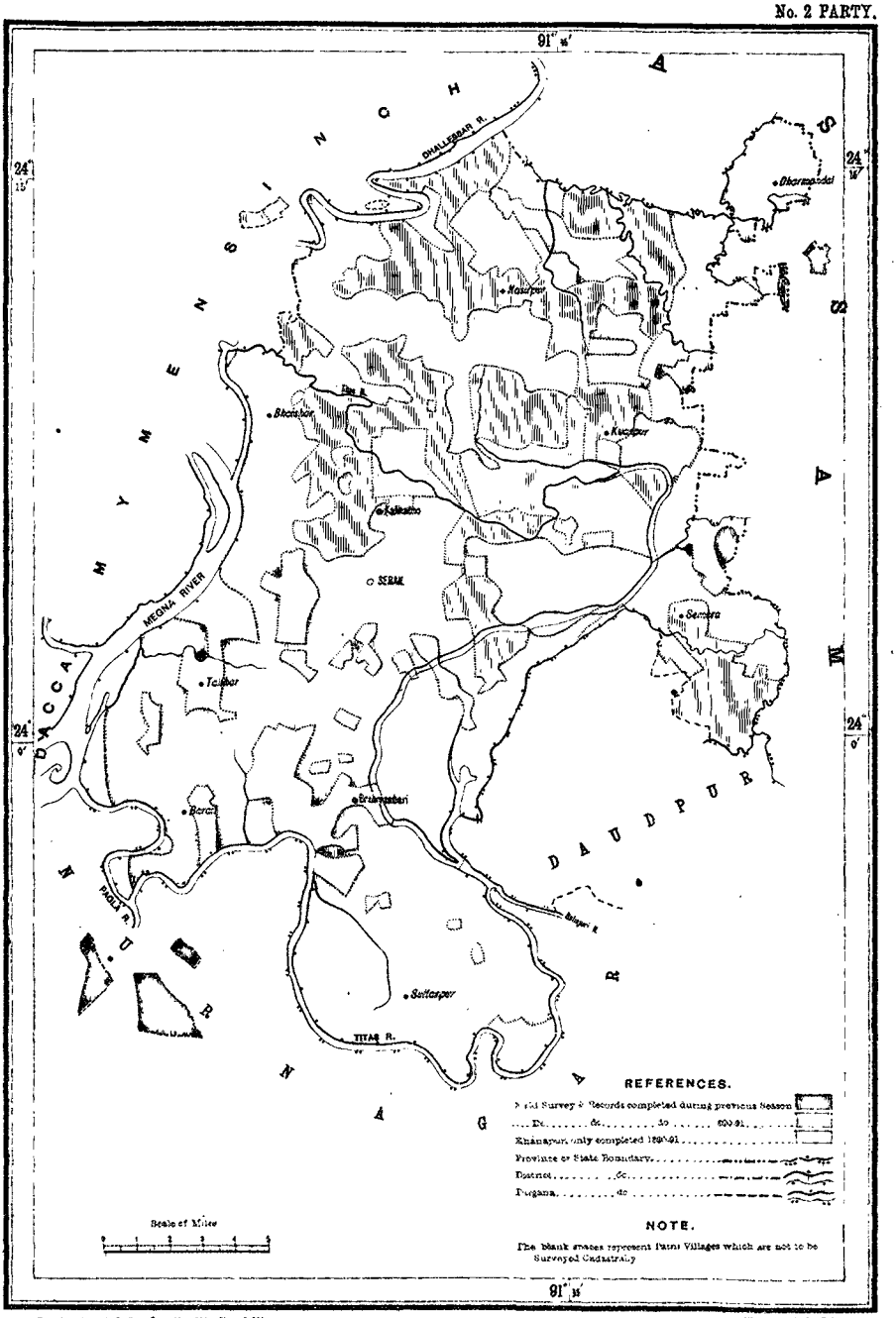
The average size of the field was ·60 of an acre. The field surveyors who were sent to complete those villages, which had been partly surveyed last year, reported having found the permanent traverse stations well preserved. Twenty-three linear miles of *partal* to check the field survey were run by the European assistants and *munsarims*, and the work was pronounced to be first class. To test the accuracy of the record-writing, 23,096 numbers were checked; the principal errors were due to the absence of the tenure-holders at the time of the record-writing. All doubtful points were put down as disputed without any attempt on the part of the survey officials to decide them.

190. The inhabitants of the *parganas* have from the beginning been much opposed to the survey, and, notwithstanding all efforts, they could never be induced to attend in a body to point out their fields; one or two only would go out, and with great difficulty be persuaded to accompany the *amins*; the delays on this account were again this season of constant occurrence. Subsequently, after numerous summonses to attend at the survey office had been issued and warnings

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY OF PARGANA SERAIL, DIST. TIPPERAH.

No. 2 PARTY.



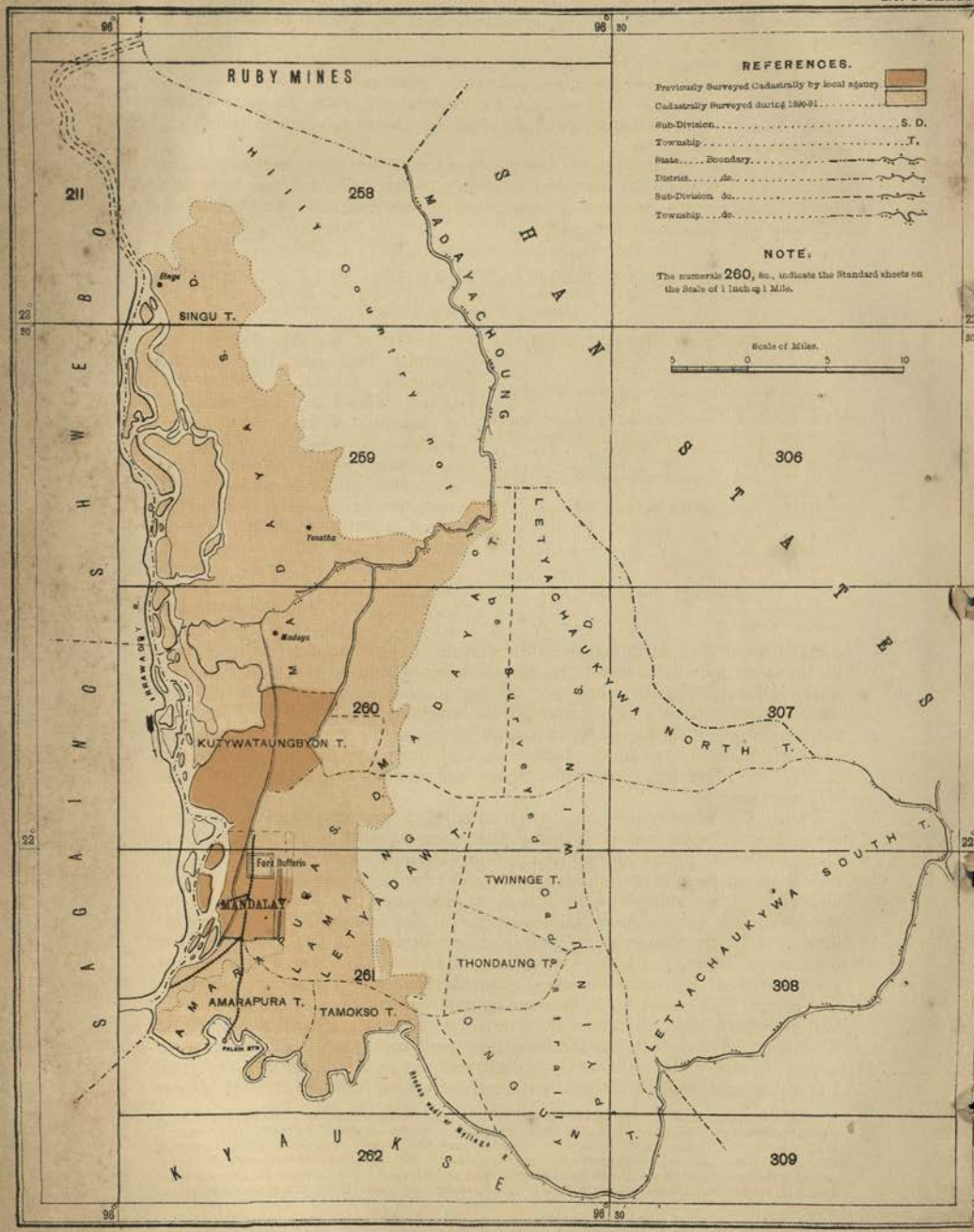
Reg. No. 367, G. I. D.—Sep. 91.—500. Rev 1,000.

Photo., S. I. O., Calcutta.

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT MANDALAY.

No. 3 PARTY.



Reg. No. 809, S. I. D.—Oct. 91.—350.

Photo., S. I. O., Calcutta.

given, which were unheeded, some fines were inflicted; these were realised by the sub-divisional officer, and then the *rayats* became more amenable and complaints were not quite so frequent. Another cause of delay was the attempt to transfer the *mehal chaks* from the *thakbust* maps on to the field sheets; owing to the inaccuracy of the old maps, only an approximation of their shape, area and position could be given; this was very unsatisfactory, but nothing better could be done.

191. The nature of the country is a low flat plain intersected with large *bhils* or marshes in every direction, and is to a great extent flooded every rainy season. This is the case more especially in that portion of the *pargana* wherein lay the season's operations, which is consequently always submerged before any other part of the *pargana*.

192. The health of the party was good on the whole; there were two deaths, one from cholera while the men were marching to the field, and the other from general debility; the *pargana* is considered by some of the officials to be the healthiest part of Eastern Bengal.*

MANDALAY AND MEIKTILA DISTRICTS, UPPER BURMA.

No. 3 Party.

193. This party, having completed the survey of the Kyaukse district, resumed field operations in the Mandalay district, of which 173 square miles had been traversed in advance during the previous season. In addition to this, arrangements were made for the traverse and cadastral survey of the *sisa*, or royal lands, in Meiktila, for which a special requisition had been made by the Burma Government, and for which a grant of ₹90,000 was sanctioned. To enable the party to cope with the work allotted to it in Mandalay and Meiktila, the establishment was strengthened by the transfer of one European assistant from the Indus riverain detachment, and three sub-surveyors and computers from the Burdwan Khas Mahals detachment; a number of cadastral hands were also added to the establishment. The nature of the work was similar to that of last year, *viz.*, the field-to-field survey of culturable areas on the 16-inch scale. The traverse and cadastral sections commenced work both in Mandalay and Meiktila on the 1st of December 1890, and closed field operations during the first week in June 1891.

Personnel.

Mr. G. B. Scott, Deputy Superintendent, 4th grade, in charge to 11th June 1891.
Mr. B. G. Gilbert-Cooper, Officiating Deputy Superintendent, 4th grade, in charge from 12th June 1891.
Mr. J. Connor, Surveyor, 3rd grade.
" J. Newland, " 4th "
" G. Campbell, Assistant Surveyor, 1st grade, to 16th March 1891.
Mr. O. D. Smart, Assistant Surveyor, 1st grade.
" P. J. Serrao, " " 2nd "
" F. P. Walsh, " " 2nd "
" W. J. Baker, " " 3rd "
28 sub-surveyors and others.

Temporary Establishment.

16 inspectors.
180 field surveyors.

194. The demarcation in district Mandalay was completed before the traverse work began, and the plans of *kwins* were supplied by the Deputy Commissioner. The greater portion of the demarcation was well done, but that of the villages in the hills and of forest tracts to the north and east of the district was imperfect. This, however, made little or no difference, as the survey operations were confined to the more level portions of the country. In the Meiktila district only the demarcation of *diangs*, or circles, was completed in time for traverse survey; the *kwin* or village boundaries were demarcated during the progress of the cadastral survey, plans being received from the demarcation officer. The *amins* took up these boundaries in the course of the survey, and they have been shown on the sheets. In Mandalay district 3,000, and in Meiktila 3,316 theodolite stations have been permanently marked, at the time of survey, by baked clay cylinders sunk flush with the ground. For the preservation of these stations the *thugyis* have been served with notices under the Upper

* Mr. Grant speaks of Messrs. McHatton and P. C. H. Smart, who were in charge of camps, as having worked zealously and heartily, and of Mr. Lee as a thoroughly efficient Assistant Surveyor. Messrs. E. F. McGowan, F. A. R. Lucas, and J. McIntyre, of the temporary establishment, have also been well reported on by Mr. Smart, who was in charge of the Serail detachment. Of the native establishment, Mr. Grant selects Babu Ramji Lall, writer, Aagamathu Mokam Dutt and Balwant Vishnu, computers, Latifulla Khan Bindalal, Hamid Hussein and Narin Purshad, sub-surveyors, and Issan Hussein, draftsman, for special mention.

Burma Boundaries Act, and provided with 2-inch skeleton plots of their *kwins* showing the number of stations to be preserved.

195. Two main and fourteen sub-circuits were run in Mandalay, and four main and six sub-circuits in the Meiktila district. The angular work was checked by azimuth observations at 46 stations in the former and at 56 in the latter district. There were 1,016 linear miles of chaining run in Mandalay and 1,980 linear miles in the Meiktila district. Two sets of chains, *viz.*, one of 100 links and one of 93 links, were used throughout the work, and proved a most useful check.

196. In Mandalay district last year, 107 villages were traversed in advance, and this year 76 more villages were enclosed by traverse; these villages covered an area of 584 square miles, or more than 3 square miles on an average to each *kwin*. The large average is due to the large tracts of hilly and forest-clad country comprised in the *kwins* near the hills; the villages in open country near the river seldom cover more than a square mile. The whole of this area has been cadastrally surveyed and mapped on 507 sheets. In Meiktila the total number of square miles traversed was 563, all of which has been cadastrally surveyed and mapped on 492 sheets. In Mandalay 551 linear miles of check survey on field book forms were run after the sheets were received in office, and 241 linear miles on plane-tables during the progress of the work: several sheets had to be rejected, but on the whole the work proved to be very good. Five hundred and eighty-two linear miles of test lines on field book forms and 269 linear miles on board plans were also run in Meiktila, the work, as a rule, being found very good, except where the limits of fields were ill-defined.

197. The out-turn of work for the field season is given in the following statement:—

Districts.	Cadastral Survey. 16-inch Scale.			Traverse Survey.	
	Number of *kwins*.	Number of fields.	Area in square miles.	Number of *kwins*.	Area in square miles.
Mandalay	183	424,247	584	76	389
Meiktila	642	376,925	563	642	575
Sagaing	...	...	...	518	714
TOTAL .	825	801,172	1,147	1,236	1,678

The average size of the field in the Mandalay district is ·89 of an acre; this is due to the large blocks of uncultivated land included in the area: in the Meiktila district it is ·95 of an acre.

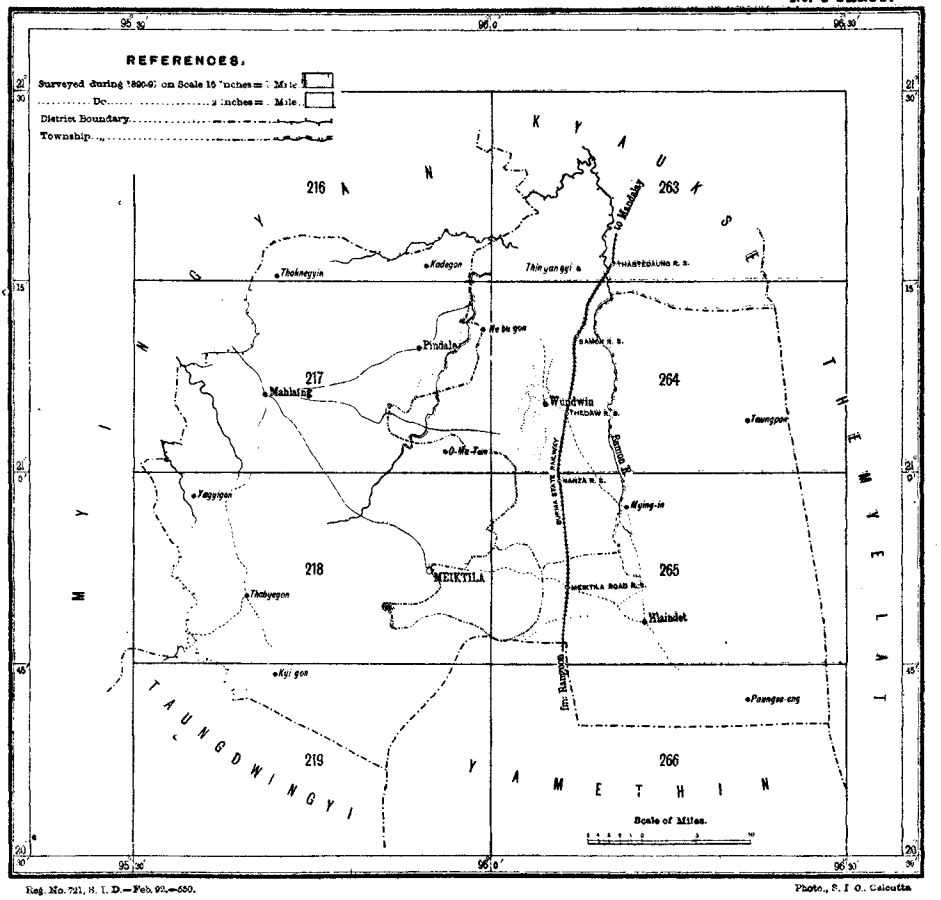
198. The average cost of cadastral survey, including demarcation, traverse, detail survey, and cost of mapping is R193 per square mile or 4 annas 11 pies per acre; the cost of the same items in Kyaukse last year was R291 per square mile or 8 annas 5 pies, showing a decrease in cost of this year's work of 3 annas 6 pies per acre. This great reduction is principally due to the following causes: (*a*) the partial employment of local labour for chainmen, whereby a saving in passage money of about R10,800 was effected; (*b*) these local men were paid daily wages per working day instead of monthly salaries, which represented a saving of about R7,200; (*c*) the increase of the native establishment in proportion to the European supervising staff, which allowed of a larger area being surveyed with no corresponding increase in the cost of supervision; (*d*) the cost of the work in Kyaukse was increased by the cost of the transfer of the party and equipment from the Central Provinces.

With regard to the first cause (*a*) it was not considered advisable to trust entirely to obtaining local labour for chaining, for fear of failure in getting men to take service, a result which might have led to serious delay or even perhaps to a stoppage of work; as an experiment it was determined to import two men with each *amin*, the other two to be obtained locally through the *thugyis*; this worked well, for when once the Burmans found that they could with confidence rely on receiving the pay promised to them, they came forward, and about 200 were employed in Mandalay at a daily rate of 4 annas, and in Meiktila of 6 annas.

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. MEIKTILA.

No. 3 PARTY.

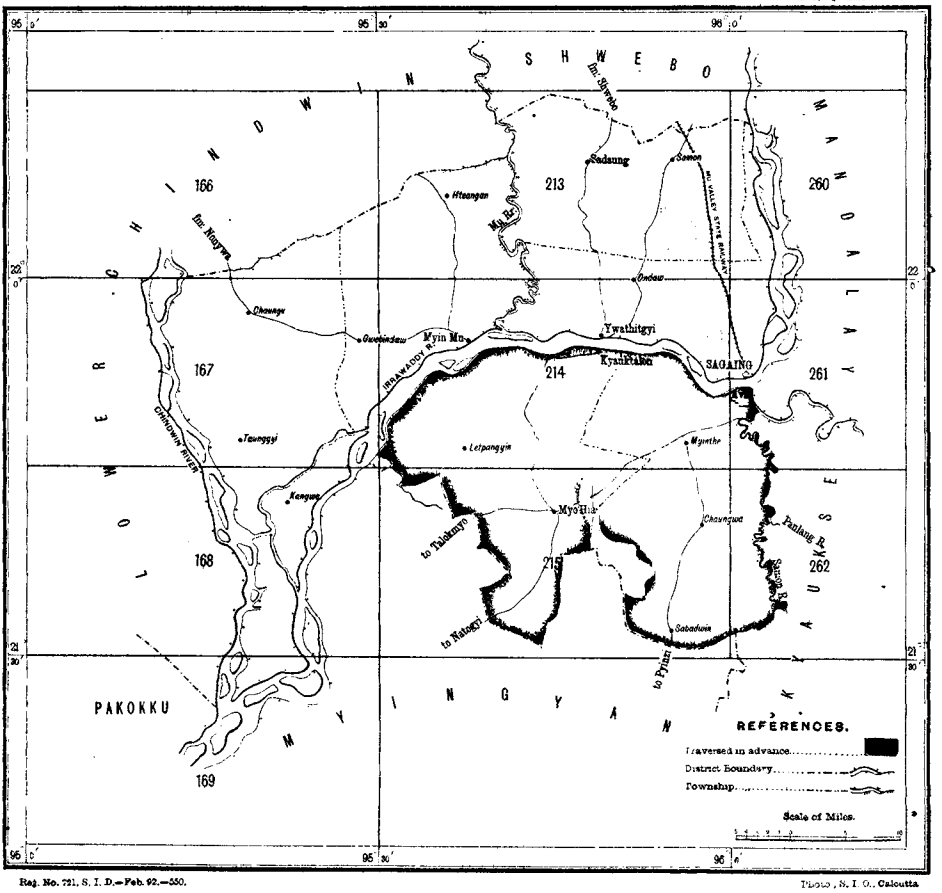


Reg. No. 721, S. I. D.—Feb. 98.—550.

Photo., S. I. O., Calcutta

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. SAGAING. No. 3 PARTY.



Reg. No. 721, S. I. D.—Feb. 92.—550.

Photo., S. I. O., Calcutta

199. The health of the party was generally good throughout the season; the only serious sickness which occurred was an outbreak of cholera among the *khalásis* on their way from India, which resulted in five deaths immediately after their arrival at Mandalay.

200. Six Burman sub-surveyors with their squads were entertained at the commencement of the season. Of these only three have worked well, and they had much difficulty in keeping their Burman *khalásis* at work. Thirty squads of Burman *amins* were also formed from men trained either in local survey schools or in the party. As a rule, they worked well in open country and when within reach of European officers, but fell off considerably when working in the villages situated in the jungles, where a lot of their work had to be rejected and re-surveyed. The average monthly out-turn of Indian *amins* during the season was 699 acres, while the average of the Burmans was 498 acres. It is therefore evident that, even if a sufficient number of Burmans could be entertained, it would not be advisable to replace the Indian *amins*, to whom the Burmans can only be looked upon as subsidiary.

201. In April, the Deputy Surveyor-General inspected the party whilst in the field, visiting the camps at Meiktila and Kyauktalon and inspecting the central office at Mandalay. The traverse camp at Kyauktalon was in charge of Mr. Gilbert-Cooper, who has been lately transferred from the Bombay Revenue Survey Department. Although, when he joined, he was unacquainted with the system of survey adopted in this department, he has already gained sufficient knowledge to enable him to hold charge of a traverse camp with credit, and during the recess he has satisfactorily superintended the whole party whilst Mr. Scott was absent on furlough. The Deputy Surveyor-General reports that he was much pleased with the progress made by the party and with the state in which he found all the records, and he desires to call special attention to the energy and excellent management of Mr. Scott, by which the large out-turn and the consequent reduced cost rate have been obtained. As already explained this was also partly due to the fact of the operations being extended to two districts. Cordial relations with the district authorities were maintained throughout the season.

202. During the ensuing field season the cadastral survey of the Sagaing district, of which 714 square miles have been traversed during the season under report, and the topographical survey of the coal-fields on the Chindwin river, in district Kendat, will be undertaken by this party.*

WESTERN DOOARS, BENGAL PRESIDENCY.

No. 4 Party.

203. This year, in addition to the cadastral survey of the Western Dooars, which was carried on in continuation of former seasons' work, this party was engaged on the topographical survey on the 4-inch scale, of the reserved forests and arable waste lands. The recess office at Hazaribagh was closed early in November, and on the 15th the field establishment assembled at a spot in the eastern sub-division of the district, 5 miles to the east of Alipur Dooar, where rough huts had been erected during the previous season for storing the field equipment of the party during the recess. Mr. Hanby held charge of the party till the 16th November, when he made over charge to Captain Hodgson, who had been appointed to the party on return from furlough.

Personnel.

Captain G. B. Hodgson, S.C., Officiating Deputy Superintendent, 3rd grade, in charge from 18th November 1890.
Mr. H. T. Hanby, Surveyor, 2nd grade, in charge from 1st October to 17th November 1890.
„ W. H. Penrose, Assistant Surveyor, 1st grade, from 1st June 1891.
„ G. T. Hall, Assistant Surveyor, 1st grade.
„ G. A. Knight, Assistant Surveyor, 1st grade, from 1st November 1890.
„ W. H. D. Ewing, Assistant Surveyor, 1st grade, to 31st May 1891.
„ L. F. Berkeley, Assistant Surveyor, 1st grade.
„ W. E. Johnson, Assistant Surveyor, 2nd grade, to 18th November 1890.
„ C. G. S. Wood, Assistant Surveyor, 3rd grade.
37 sub-surveyors and others.

Temporary Establishment.

140 field surveyors, inspectors, &c.
76 computers, draftsmen, &c.

204. The remarks that were made last year as to the divisions into which the

* The officer in charge reports thus on the services of surveyors and others: Messrs. Connor, Newland, and Smart, who respectively supervised the cadastral camps in Mandalay and Meiktila and the traverse camp, performed their duties most satisfactorily, and Messrs. Serrao, Walsh, and Baker showed themselves to be trustworthy, hard-working and efficient assistants. Of the native establishment he specially mentions Bhugobutty Charan Chuckrabutty, Kedar Nath, Bhola Nath, Rohan Lall, Harpat Rai, Fushatulla, Alimsuddin, Karim Baksh, Maksud Ali, and Mansur Khan.

lands of the Western Dooars are separated may be recapitulated, as they will serve to explain the terms made use of in the report:—

"The only territorial divisions bearing definite names in the Western Dooars are *parganas* and *talukas*; the latter are sub-divided into plots of various sizes, called *jots*, which are distinguished by the name of the tenant (*jotdar*) or of his successor, and by serial numbers called *tauzi* numbers. The *taluka* is too large and the *jot* too small to serve as a survey unit, so it was decided to club together several *jots*, so as to make up areas approximating to the size of the *mauza* or village in the North-West Provinces, and to treat them as the unit for the traverse survey, but the *jot* is the unit recognised for settlement purposes. These blocks of congregated *jots* are called *chaks*, which have been numbered consecutively for each *taluka*."

205. During the season a further area of 420 square miles was traversed, which completes the entire district, with the exception of a large area to the west of the Torsa river, which has been recently surveyed by the local survey and blocked out for allotment as grants for tea cultivation. The total area traversed in the plains during the three seasons the party has been employed in the Dooars is 1,606 square miles, in addition to which, during the present season, an area of 25 square miles of the hilly portion of the district has been traversed and 18 square miles triangulated, making in all an area of 1,649 square miles prepared for detail survey. Of this area 759 square miles, consisting mostly of cultivated land, have been surveyed cadastrally, 525 during former seasons and 234 during the present season. The reserved forests cover an area of 487 square miles, of which 174 have been surveyed this season on the 4-inch scale, leaving 313 square miles for survey next season. The waste land consists of 43 square miles of hilly country and 360 square miles of arable land in the plains, which has been divided into blocks averaging 915·36 acres, for future allotment for tea or general cultivation: of the arable area 56 square miles have been surveyed topographically on the 4-inch scale during the present season.

206. As in previous seasons prism-shaped stones, about 2 feet in length, were employed to mark the tri-junctions of *chaks* in the cultivated lands and the triple or quadruple junctions of blocks in the waste lands, the number embedded being 274. Intermediate stations were marked with vitrified bricks as a rule, but in the forests a certain number of large bamboo stakes was employed for this purpose, and on the Bhutan boundary theodolite stations were generally marked by stones picked up on the spot and a cairn erected over them.

207. The cadastral survey was very much scattered, and comprised the completion of *parganas* Chakwakheti and Baxa (which had been partly surveyed the previous season), all existing cultivation of a permanent nature in Bhatibari and Bholka, Hidayat Ali's estate in Lakhipur, and detached plots in Moraghat and North Mainaguri, which had been omitted at the time these *parganas* were surveyed on account of their not having been demarcated. With the exception of a few detached plots, amounting to 5 or 6 square miles, which could not be surveyed before the advent of the rains, the cadastral survey has been completed of all cultivation of a permanent nature throughout the area allotted for survey. The writing of the records in the field, of 40 square miles surveyed last year, was done in addition to that of the whole area surveyed this season.

208. The procedure adopted last year for dealing with disputed boundaries was again followed. Tracings in duplicate of the localities in dispute were sent to the settlement officer, with notes to assist him in his decision. The boundary that agreed most nearly with the old records was adopted as a rule, and when the case was decided one copy was signed and returned to the survey office for record.

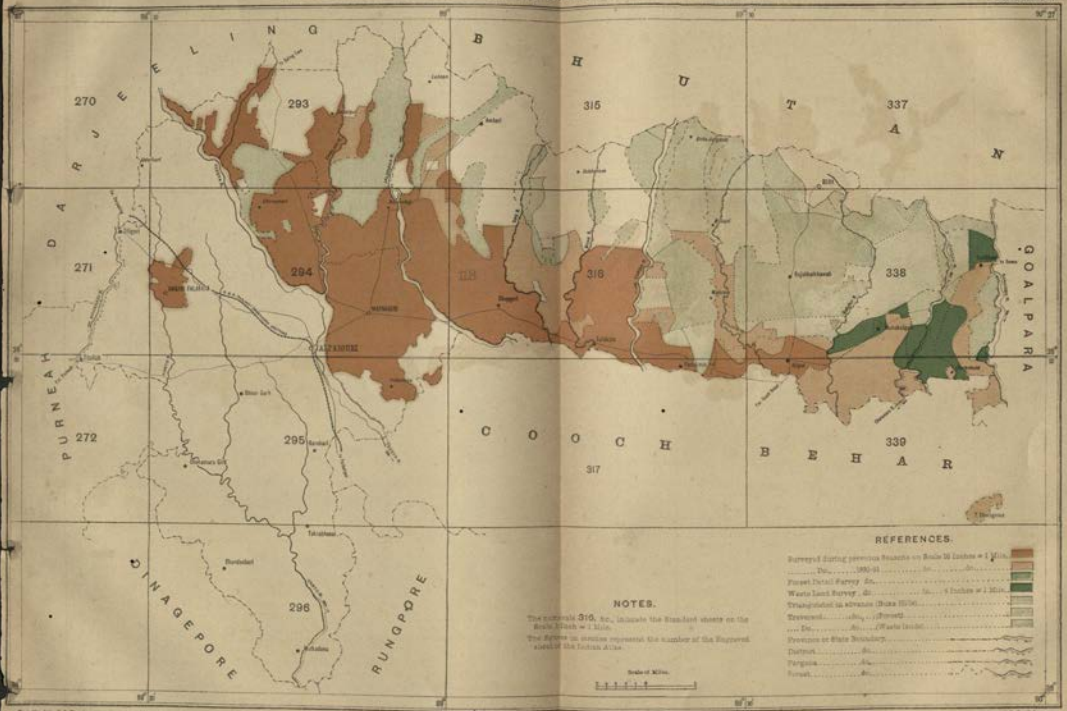
209. The forest survey was confined entirely to the Baxa and Borajhar reserves: of the former, as much as is situated in the plains; and of the latter, the whole of the southern block was completed and a portion of the northern block. The area surveyed was 174 square miles, which was checked by 59 linear miles of test lines and mapped on 26 sheets. The average number of plane-tablers employed was 10, and each man's average out-turn per month was slightly under 3 square miles.

210. *Pari passu* with the mapping of the topographical features, the limits of the various forest growths were delineated by the sub-surveyors as well as the different classes of soils. The forest growths are divided into five classes:—(1) Pure *sál*, (2) *sál* with mixed forest, (3) mixed forest without *sál*, (4) *khair* and *sissu* forest, and (5) savannah or grass lands.

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN THE WESTERN DOOARS (DIST. JALPAIGURI).

No. 4 PARTY.



There are four classes of soils—(*a*) very good, (*b*) medium, (*c*) dry, and (*d*) moist and swampy. These details are recorded on the field sheets merely by the figures and letters as given above, the limits being shown by dotted lines; but for the Forest Department tracings of each sheet have been prepared, in which the forest growths are shown by washes of colour and the soils by parallel lines drawn across the map, the direction in which the line is drawn indicating the class of soil. In accordance with the wishes of the Deputy Conservator of Forests, on each tracing the area has been entered separately for three classes of forests, *viz.*—(i) forest in which *sâl* is found, (ii) *khair* and *sissu* forest, (iii) forest without *sâl*. The tracings have been numbered in accordance with the field sheets, and an index map has been prepared, which will be sent with the tracings to the Forest Department.

211. The small area of waste land surveyed topographically on the 4-inch scale consisted mostly of detached portions in sheets in which the cultivation only had been surveyed cadastrally in *parganas* Bholka and Bhatibari. The area thus surveyed amounts to 56 square miles, comprised in 21 sheets, of which only 14 were completely and 7 partially surveyed; very few of these sheets have been checked as yet.

212. Field work was commenced about the 25th November 1890, and closed during the first week of June 1891. This year again an establishment for completing the 16-inch maps and vernacular records was left at Jalpaiguri under Mr. Hanby for convenience of communication with the settlement office.

213. The out-turn of cadastral work for the season is given in the following statement:—

Parganas.	Traverse Survey.		Cadastral Survey, 16-inch scale.					Remarks.
	Number of *chaks* and blocks.	Area in square miles.	Number of *chaks*.	Number of *jots*.	Number of fields proper.	Number of *kiaris* (sub-divisions of fields).	Area in square miles.	
Chengmari	...	...	2	14	132	...	1·06	
North Mainaguri	...	...	20	101	1,550	874	5·30	
Moraghat	...	...	34	688	15,063	4,940	33·50	
Lakhipur	102	65·96	93	774	38,472	8,164	52·20	
Madari, West	...	...	4	52	2,176	249	4·22	
„ East	...	...	13	24	1,449	315	10·22	
Chakwakehti	...	...	13	53	3,909	2,325	12·47	
Baxa	...	...	32	223	12,630	5,183	27·24	
Bhatibari	...	...	71	1,040	41,977	12,843	49·92	
Bholka	4	1·04	58	763	41,360	55,602	37·78	
Total ...	106	67·00	340	3,732	158,718	90,495	233·91	

The out-turn of other classes of work was as follows:—

Parganas.	Traverse Survey.		Detail Survey, 4-inch scale.	Remarks.
	Number of blocks.	Area in square miles.	Area in square miles.	
Waste land Survey	129	171·64	55·70	
Forest Survey	7	182·12	174·22	
Total	136	353·76	229·92	

In addition, 66·9 linear miles of the boundary between Jalpaiguri and Bhutan were traversed with a view to relaying the boundary.

214. The number of theodolite stations is 6,825, of which 274 were marked by stones, and the remainder by bricks, except in some places on the Bhutan boundary, where stones picked up on the spot were used, and in a few cases in the forest where wooden pegs were driven in. The average number of stones per square mile in the cultivated lands is 1·27 and in the waste lands 1·02. The average cost per square mile for permanent marks over the whole area traversed is ₹5·8.

215. The average size of the fields in the cadastral area is 0·94 of an acre, exclusive of the sub-divisions of the fields, and 0·60 of an acre including them. The sub-divisions of the fields, as they are called, are shown on the field sheets and also on the tracings by dotted lines as heretofore, the limits of the fields proper being shown with firm lines. These distinctions, however, are purely arbitrary, as the sub-divisions really show the fields proper as they appear on the ground, several of these being clubbed together under one number to keep the numbers within reasonable limits; the number of fields included in one number being limited to those which in one compact plot are all on one level, and so can be classed together under one soil head. This work is performed by the *mohurrir* when writing up the records, who, guided by the above considerations, decides how many fields shall be included under one number. The *amin* or field surveyor makes no distinction on his map, but shows all the field boundaries alike. Thus, this season, there were 158,718 fields numbered, while the actual number of fields surveyed was 249,213. The cost rate per field, for both survey and *khanapuri*, has been calculated on the actual number of fields surveyed.

216. No change has been made this year in the preparation of the records in the field, but the areas which had previously been entered in the *khasras* in English are now required to be entered in the Bengali character, and in the tracings the colour hitherto employed for tobacco land has been omitted according to orders received, and all such land shown merely as *farringhati*. In the estate of the late Colonel Hidayat Ali in Lakhipur *pargana*, where there are no *jotdars*, the holdings of *chukanis* or tenants have been shown as *jots* on the field sheets, with the difference that the limits are not shown with thick firm lines as in the case of *jots*, but by broken lines carried alongside of the field boundaries. Separate tracings and records have been prepared of each *chak* and not of each *chukani*.

217. The cadastral survey was tested by 428·73 linear miles of check lines, and the *khasra* entries of 69,611 fields were also checked either by European officers or by native inspectors. The season's out-turn has been mapped on 428 sheets, which cannot be finally disposed of or submitted for publication till settlement has been effected. Before the field sheets can be completed and the records prepared for the Settlement Department, all *jot* boundaries have to be compared with the old records of the district when such are forthcoming, and owing to the unsystematic manner in which these papers have been kept and various other causes, the hunting up and identifying of the *jots* has proved a most tedious and laborious task, involving as it does for each *jot* the looking through, time after time, of a vast number of maps in separate bundles. A great many of the old records bear no distinguishing number; many of the *jots* are shown as situated in totally different *taluks* to those in which they really lie, and many *taluk* names are given which are not to be found in the list of *taluks* now received from the settlement office. In the northern part of *pargana* Bhatibari much time was lost in looking for *jots* in heavy grass jungle, the survey of which was asked for, but which had not been demarcated. Eventually on a reference being made to the settlement officer, the *jots* were demarcated and men sent back to survey them. The difficulties are further increased in this district by the absence of localities bearing definite names, so that the situation of a *jot* is traced with great difficulty. The name of the original proprietor is recorded, but the changes in proprietorship are found to be frequent, and often all traces of the originally allotted area have disappeared, the land having been either sold to, or absorbed by, the adjoining *jotdars*, or having been abandoned, has been re-distributed to fresh applicants, while the old records are still preserved without any note on them of such transactions.

218. The writing of the records in the field was almost entirely done by Bengali *mohurrirs* in the vernacular of the province. A survey school was

established to provide a sufficient number of Bengalis for this purpose at the commencement of the field season under a Bengali inspector, who, at the end of a month, produced 15 men ready to take up *khanapuri* independently, after having learnt to read a map and to make small corrections therein if necessary.

219. The local difficulties met with in former seasons were intensified this year, as, in addition to the usual maladies incidental to the district, an outbreak of cholera occurred at the commencement of April which caused some deaths and many desertions both among *amins* and *khalásis*, and caused the field work to be prolonged throughout May, which it was hoped to avoid, as the district becomes very unhealthy then. The rains began early in the first week of May, but as so very little remained to be done to complete the cadastral survey of the entire area allotted for survey, the work was continued in the hope that every day would see that little finished. The rain and the consequent sickness however proved beyond all calculation—both *amins* and *khalásis* refused to work in localities where the cholera was raging, and in other places the inhabitants would not permit them to work for fear of their bringing the disease. At the very outset the want of *khalásis* had been much felt, a sufficient number not having been entertained prior to taking the field, as in the previous season a certain number of men had been obtained locally, and arrangements were made accordingly. As soon as it was found that more measurers were wanted, a fresh batch of 200 was sent for from Hazaribagh and 187 were entertained and started off. Out of these only 7 or 8 men joined the party, the rest having turned back when within a few days' march of Jalpaiguri. In addition to the drawbacks above enumerated, the very scattered nature of the work, consisting of detached plots in almost every *pargana* of the district, as well as the large amount of jungle that was met with interspersed with the cultivation, has tended to enhance the cost of the survey. The cost rate per acre on traverse and cadastral survey is 8 annas 3 pies.

220. Of the local civil authorities from whom assistance was required, Colonel Boileau, the Deputy Commissioner, Mr. Gouldsbury, the District Superintendent of Police, and Mr. W. M. Green, Deputy Conservator of Forests, were always ready to help the survey in every way, and so were the *tahsildars* of Falakata and Bholka, the latter especially. The sub-divisional officer at Alipur Dooar, however, not only made no effort to give assistance, but generally took no notice of letters addressed to him by Captain Hodgson or his assistants. The survey operations which lay principally in his sub-division were seriously hampered by his want of courtesy and the example he set to his subordinates, who took their cue from him. To Dr. Rivers Anderson of the 9th Bengal Infantry, the Forest Survey section was much indebted for his kindness in placing the services of the Hospital Assistant at Rajabhatkhawa and the dispensary there, at the disposal of the party.

221. In the recess office at Hazaribagh a small establishment was employed in finally examining the cadastral sheets, of which 212 were ready for despatch to head-quarters by the end of September, and it was expected that 100 more would be ready before the party left for the field, but none of these can yet be despatched, as they are required for the preparation of the 2-inch standard quarter sheets which were commenced during the recess. Of these the drawing of two sheets, Nos. 294 S. W. and 295 N. E., has been completed, and also of 6 sheets, as far as surveyed, Nos. 293 N. W., S. W., 294 N. W., 316 S. E., N. E., 338 N. W., while Nos. 293 S. E., 294 S. E., N. E., 316 S. W., and 338 S. W., are in hand, and the drawing, as far as materials are available, will be completed by the end of October.

222. It having been decided to fill up such portions of the 2-inch quarter sheets as have not been surveyed during the present operations, from the maps of tea lands locally prepared, 63 of these maps were obtained from the Deputy Commissioner, Jalpaiguri, for the purpose. These maps are generally on the 8-inch scale, and they have been fitted together and pentagraphed in a block on separate paper, and the topographical details will be traced on to the fair sheets, the exterior boundaries of the blocks having been traversed during the present survey.

223. The area of reserved forests surveyed was comprised in 14 sheets, of which the drawing of all has been completed for reproduction on the 4-inch scale. They have also been drawn on the 2-inch scale for incorporation into

the general map of the district, which is reduced and published on the 1-inch scale. The typing of the 4-inch sheets is in progress.

224. The following statement shows the quarterly despatch of complete records to the settlement officer at Jalpaiguri. The total area of which the records have been supplied up to the end of September is 462·3 square miles exclusive of 5·6 square miles revised; the areas of which the records have still to be despatched is 306·4 square miles:—

Quarters.	Records of seasons 1888-89-90.			Records of season 1890-91.		
	Number of *mauzas*.	Number of fields.	Area in square miles.	Number of *mauzas*.	Number of fields.	Area in square miles.
October, November, and December 1890	474	34,380	31·58	...	...	...
January, February, and March 1891	1,061	54,109	45·46	...	...	...
April, May, and June 1891	580	46,134	49·61	61	457	2·62
July, August, and September 1891	625	50,980	66 49	632	7,462	31·00
Totals	2,737	185,603	193·14	693	7,919	33·62
Remaining	859	32,957	64·42	3,689	185,113	241·98

225. The programme for the ensuing season is the completion of the topographical survey of the Western Dooars. The survey of the reserved forests will be continued on the 4-inch scale, but it has been decided by the Bengal Government that the classification of forest trees and soils shall not be done by the Survey Department: the area of forests remaining for survey is 313 square miles. The waste lands, covering an area of 323 square miles of plain country and about 43 square miles of hills, will be surveyed on the 2-inch scale, but the topographical features to be depicted will be confined to the details sufficient for a 1-inch map. One section of the party will be employed throughout the season in completing the records of the cadastral survey of former seasons which have to be furnished to the settlement office, and will also undertake the cadastral survey of several detached *jots*, aggregating about 5 or 6 square miles, which, for various reasons, were omitted previously. In addition, arrangements will be made for re-laying, in conjunction with the civil authorities, the boundary between the Western Dooars and Bhutan.

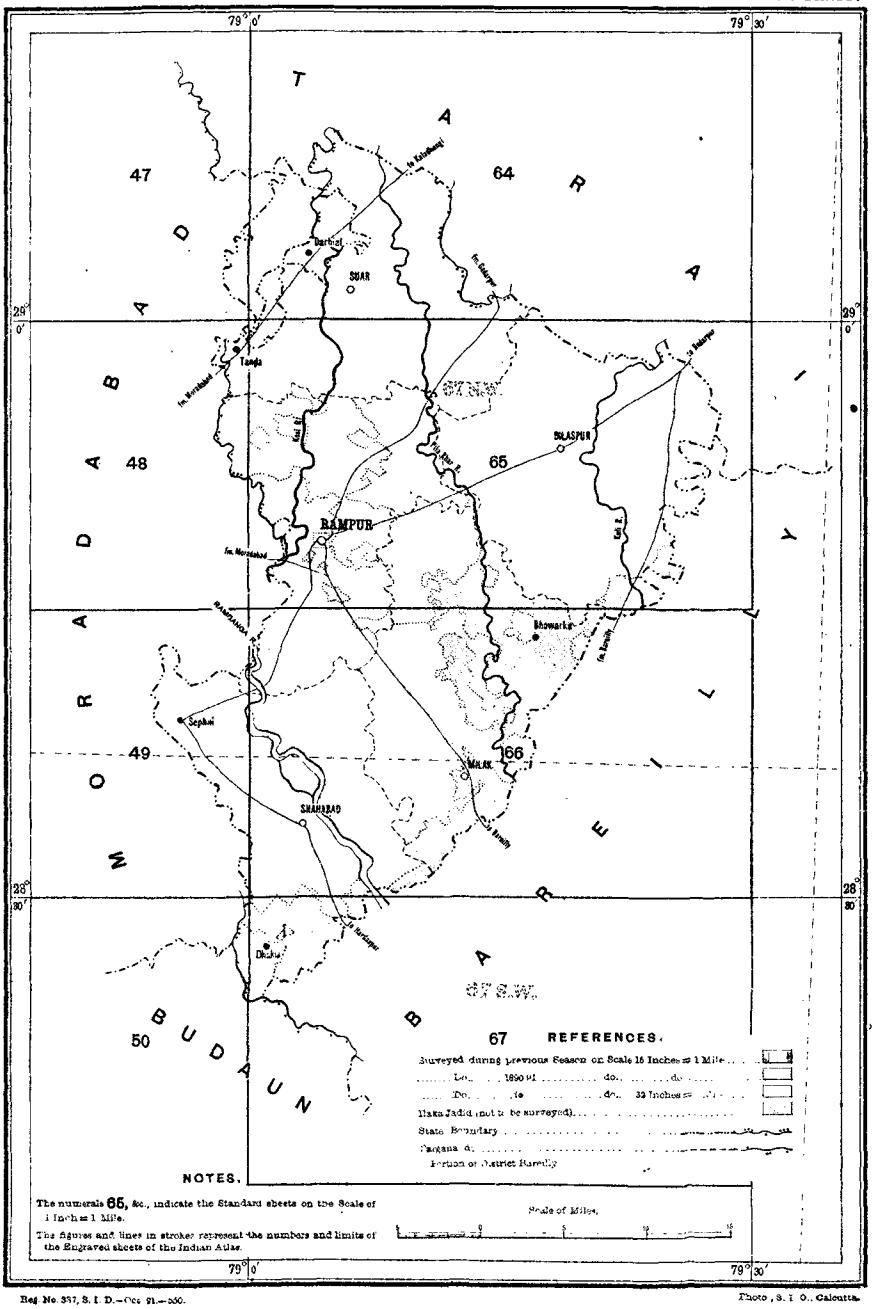
226. The Deputy Surveyor-General, Revenue Branch, inspected the cadastral section and office at Jalpaiguri on the 31st March, and on the 1st April attended a conference with the Lieutenant-Governor of Bengal, the Commissioner of the division, and the Settlement Officer, when the progress and the future work of the party was discussed and arrangements made for the more speedy supply of records to the Settlement Department. Again, on the 5th October the cadastral office was inspected; on both occasions the books of the party and the preparation of the records were inspected and approved of. On the second occasion complaints having been made by the settlement officer that the number of records which had been promised by the end of August had not been supplied, enquiries were made on the subject, and it was found that the complaints were greatly exaggerated, and that though there were still a few due, the actual number sent in was much in excess of what had been stated by the settlement officer, and it was not considered advisable to order any immediate increase of establishment to complete the very small number remaining. Mr. Hanby, who was in charge of the cadastral section, was authorised to entertain more hands if they could be procured and if he deemed it necessary, but he was at the same time cautioned against incurring extra expense without sufficient reason.*

* Captain Hodgson speaks in high terms of Mr. H. T. Hanby's ability and zeal; and states that his thorough knowledge of details and capacity for work have been of the greatest assistance to him: he has been in charge of the record section at Jalpaiguri all the year. He reports favourably of Messrs. W. H. Penrose, G. T. Hall, L. F. Berkeley, W. H. D. Ewing, and C. G. S. Wood. Of the sub-surveyors, he selects for special mention Jagneswar Bhattacharji, Irfan Ali, Ramjas Misr, Patandin, Abdul Karim, Ramnarain, Nand Lall and Durjan Ram.

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN THE RAMPUR STATE.

No. 5 PARTY.



Reg. No. 337, S. I. D.—Oct. 91.—350.

Photo., S. I. O., Calcutta.

NORTH-WEST PROVINCES.

No. 5 Party.

Personnel.

Lieutenant-Colonel J. E. Sandeman, S.C., Deputy Superintendent, 2nd grade, in charge up to 30th June 1891.
Lieutenant R. T. Crichton, S.C., Assistant Superintendent, 2nd grade, in charge from 30th June 1891.

Rampur State Section.

Mr. A. W. Smart, Assistant Surveyor, 1st grade.
„ J. Murphy „ „ „ „
6 sub-surveyors.
16 inspectors.
169 field surveyors (*patwaris*).
63 field surveyors (*amins*).

Garhwal Section.

Mr. T. F. Freeman, Surveyor, 4th grade.
„ N. Bedford, Assistant Surveyor, 2nd grade.
„ W. V. Skilling, „ „ „ „
„ J. H. Murphy, „ „ „ „
15 sub-surveyors.
16 inspectors.
31 field surveyors (*patwaris*).

227. This party, of the strength shown in the margin, has continued cadastral operations in the Garhwal district and in Rampur State, North-West Provinces. It also undertook the survey, on the 4-inch scale, of the forest reserve in the Lansdowne cantonment. These operations will be reported on separately.

Survey of the Rampur State.

228. When the orders for the survey with record of rights were received, it was arranged with the authorities that it should be made on the 16-inch scale, and that the estate known as the *jadid ilaka* should be entirely excluded from the survey. Field operations were commenced on the 20th October 1890 and closed on the 10th June 1891. During the previous season 577 square miles of traverse survey had been completed, and the small remaining area was finished by 6 traverse surveyors by February 1891.

229. The following table gives the out-turn and details of the traverse survey :—

Number of village circuits.	Number of sub-traverses.	Number of traverse stations.	Number of permanent marks.	Area in square miles.
308	777	8,959	5,932	212·75

At the request of the Council, clay cylinders, in preference to stones, were embedded at the theodolite stations and covered over with substantial mounds of earth. The traverse survey was carried out under very favourable conditions, the country being quite level and the mathematical results are in consequence very satisfactory. A comparison between the two trigonometrical stations of the North-East Longitudinal Series which were connected with in the previous season, shows the traverse error in direct distance to be 1·18 feet per mile.

230. The services of 169 *patwaris* were made available for the cadastral survey; but as the area to be dealt with was large, this number was not sufficient, and it was found necessary to supplement the working agency by 63 *amins*. It is to be regretted that the State authorities could not spare a sufficient number of men to enable the services of the *amins* to be dispensed with altogether. The out-turn of cadastral survey during the season has been 723·75 square miles, containing 992 villages and 527,249 fields, the average size of the field being 0·88 acres. The cost rate of the cadastral work and record writing, excluding traverse, has been 1 anna 9 pies per acre, or R70-2-6 per square mile: during the operations 229 cases of disputed boundaries occurred and were disposed of.

231. The following tabular statement gives the statistics for the whole State

(excluding the *jadid ilaka*), the survey and record of rights of which has now been completed:—

Pargana.	Number of villages.	Number of fields.	Area in acres.	Area in square miles.	Cost.	Rates for complete survey and village records		Number of 16-inch sheets.	Number of 32-inch sheets of the city.	Number of 2-inch standard sheets.	Remarks.
						Per square mile.	Per acre.				
					R	R a. p.	R a. p.				
Suar	272	131,500	122,607	191·57	75,530	95 10 2	0 2 4	1,341	7	16	101 villages, containing 49,715 fields, area 66 square miles, were surveyed in season 1890-91.
Bilaspur	225	135,365	123,736	193·34							
Rampur	265	140,536	112,695	176·08							
Shahabad	192	89,716	91,010	142·20							
Milak	139	79,848	55,398	86·56							
TOTAL	1,093	576,965	505,446	789·75	75,530	95 10 2	0 2 4	1,341	7	16	

232. To the cost, *viz.*, R75,530, as shewn in the above table, there are still some small sums to be added, such as cost of instruments and expenditure during October 1891, but the total cost will not exceed the estimate which was submitted for a survey to be made by a combined establishment of *patwaris* and *amins*: it has been made principally through the agency of *patwaris*, and if it had been possible to have dispensed altogether with the *amins*, the cost would have been greatly reduced. The total area of the Rampur State, including the *jadid ilaka* which contains 120·7 square miles, is 910·4 square miles.

233. In order to ascertain if encroachments have been made, the boundaries of the British districts which march with those of the State have been transferred from the latest settlement records, on to the sheets of the new survey and they have been found generally to agree with the surveyed boundaries.

234. On 13th December 1890, the Council decided to have a 32-inch scale survey of the city also made. This survey is based on small polygons 4·57 acres in size, which have been traversed with the theodolite; 2,189 stations, have thus been fixed, so that there is little room for error in the detail survey. The city is divided into 9 *thanas*, and has an area of 2·57 square miles. The scale being so small for the purpose, a group of houses has been made the unit of survey, masonry buildings being distinguished from mud huts; the interior courtyards to which there was no access have not been surveyed.

235. The 16-inch survey is mapped on 1,341 sheets and the 32-inch scale city survey on 7 sheets. The latter map is coloured and is under preparation for the State; tracings of the 16-inch sheets have been lodged with the State authorities. The work has been carefully tested, the check surveys averaging 4·35 linear miles in each square mile of survey, while the check lines aggregate 2,100 linear miles in length, of which 1,035 miles are independent, *partals*, or were run by the European assistants. The Deputy Superintendent personally tested some of the *amins'* work and reported very favourably on it, and Mr. Smart describes it as being first class. The record of rights (*khasra*) which has been written during the progress of the survey contains 576,965 numbers. The tenants have no permanent rights but occupy their land on a yearly lease, and are not disturbed while they pay rent to the farmer to whom the *mauza* is leased. The rent levied depends on the rate per *bigha* which varies with the known fertility of the field. From the *khasra*, the *milan khasra* and the *jama-bandi* have been extracted; these, together with a coloured trace of the 16-inch cadastral map, form the *misl* (file of papers) for each village.

236. The State is being mapped on sixteen 2-inch standard sheets. As the *jadid ilaka* has not been surveyed, it must either be omitted from the mapping, or the topographical details must be transferred from old non-professional maps.

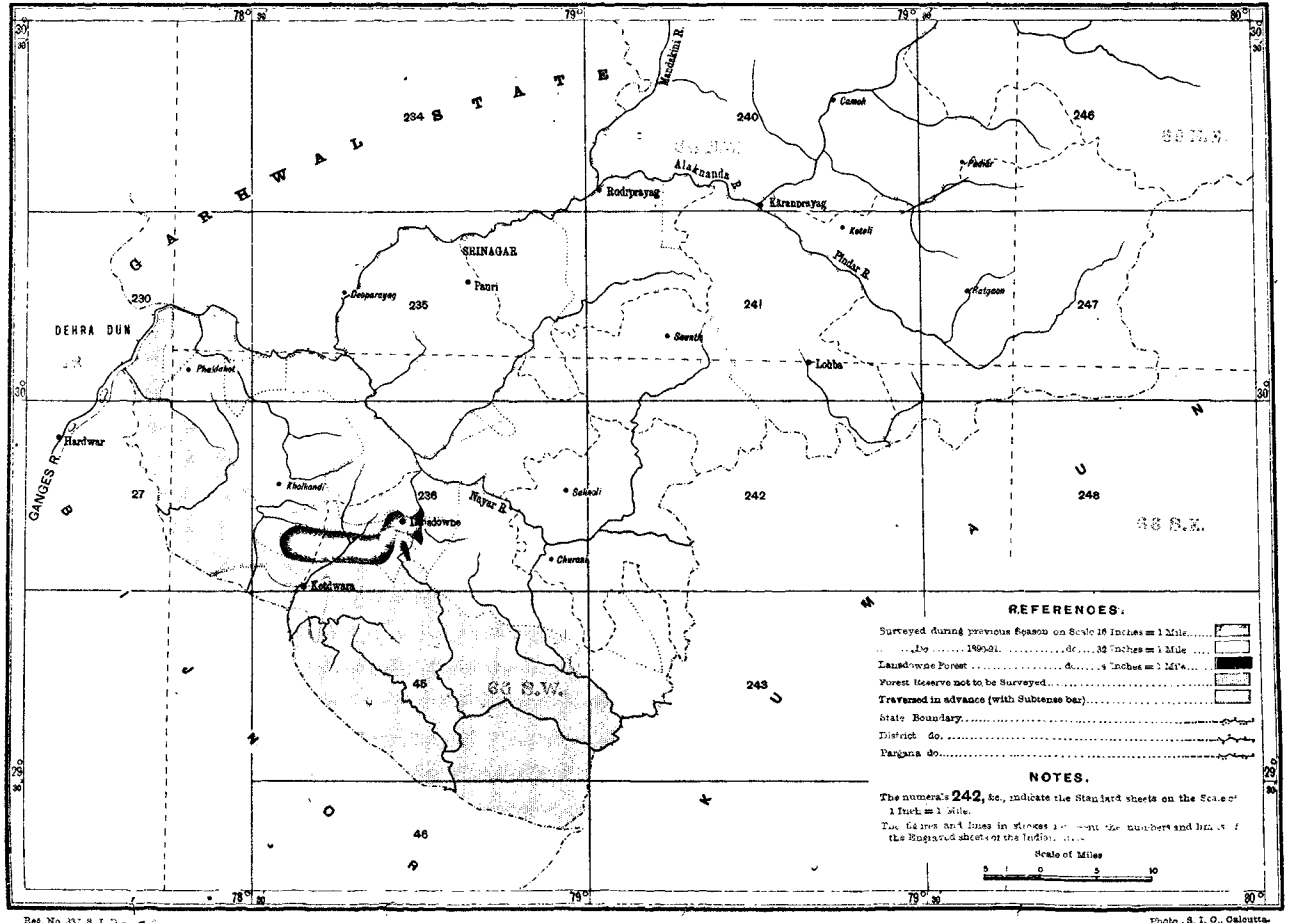
Survey of District Garhwal.

237. It having been decided that the survey of Garhwal should be resumed, field operations were commenced early in October 1890, with a mixed establishment of Hindustani and *pahâri* (hill-men) surveyors, and were continued until the 15th of June 1891. Many of the Hindustani surveyors who had promised to come did not do so, and the establishment of *pahâris* was very inadequate.

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. GARHWAL.

No. 5 PARTY.



Reg. No 337. S. I. D.

Photo., S. I. O., Calcutta.

238. The system of traversing with the subtense bar as described in the last Annual report was continued, stations being fixed all over the cultivated area from 15 to 30 chains apart. The traverse survey was carried over the rest of the Barasyun, Dewalgarh, and Chaund Kot *parganas* and over portions of Mala, Tala, and Ganga Salan and Chandpur *parganas*. The accompanying statement gives the out-turn of the season's traverse work :—

District.	Number of main traverses.	Number of sub-traverses.	Number of stations.	Number of permanent marks.	Area in square miles.
Garhwal	164	1,405	18,090	17,638	845

The traverses emanated from, and closed on, 373 trigonometrical stations, the azimuths to check the angular work being derived from these same stations. The linear miles measured aggregated 4,366.

239. The permanent marks embedded are rough uncut stones over which mounds of loose stones are piled. They have been placed in charge of the *padhans*, from whom receipts have been taken. The cost of the season's traverse out-turn has been R27,710, which gives a rate of R32-12-8 per square mile. The area remaining for traverse survey cannot be closely estimated: it may be 1,000 square miles and it may be 1,500 or even more. If it is not intended to carry the survey into the northern *parganas*, it should be completed in one season. Parts of the Tala, Mala, and Ganga Salan, Dewalgarh, Chaund Kot, and Chandpur *parganas* have been traversed in advance.

240. The season's out-turn of cadastral survey on the 32-inch scale embraces the whole of *pargana* Barasyun, and the total area of this tract is 299½ square miles. But leaving out of account large pieces of waste land, the cadastral survey covers an area of 189·17 square miles, comprising 131 square miles of assessable land, the balance consisting of small scattered patches of waste land. The surveyed area covers 9 *paitis* and 1,054 *mauzas*, which contain 770,804 fields. The size of the field calculated on the assessable area only is 0·11, and on the cadastral area it is 0·16 of an acre. The cost of the cadastral survey amounts to R53,466-9-7. The rates therefore are R282-10-2 per square mile, Ro-7-2 per acre, and Ro-1-1 per field. These rates have been obtained by distributing the cost over the cadastral area (assessable area *plus* small patches of waste) only; but for comparison with the cost rate of other surveys, it should be spread over 299½ square miles or the whole area of the tract surveyed, for the waste which has not been included in the surveyed area is so scattered, that it would certainly be included under the system of calculating cost rates in the plains. The rates, if the cost were thus distributed, would be R178-8-3 per square mile, Ro-4-5 per acre, and Ro-1-1 per field. The cost of this survey is much above the original estimate, but this was unavoidable; the reasons for it were explained in paras. 230 and 231 of the General report for last year. The principal ones are the physical difficulties of the country and the absence of any local establishments whose services it was hoped might have been employed on the survey, and the impossibility of inducing a sufficient number of good *amins* from the plains to take service in Garhwal, more particularly when they knew that there was no chance of more work after that was completed. The stoppage of the cadastral surveys in the North-West Provinces has had the effect of scattering the old trained hands so that when they were wanted, it was found difficult to get any of them. Another reason for the high cost is that the area under cultivation was enormously under-estimated as stated in para. 232 of last year's report, and in addition to this, the excessively minute sub-division of the land amongst different occupants added considerably to the labour of survey.

241. In consequence of the very small size of the field, areas have been extracted to the third place of decimals of an acre and converted into *bisis* (4,800 square yards), *nalis* ($\frac{1}{20}$ *bisi*), and *annas* ($\frac{1}{16}$ *nali*) whilst a suitable deduction is made for interior terrace walls. The differences in assessable area as found to exist by the present survey and as recorded by the old settlement are very great. For instance, the approximate assessable area (the final area cannot

be given yet) of the tract under survey is 130⅜ square miles, but of this only 52¼ square miles are at present assessed. The loss to Government in revenue over this area is therefore very nearly 150 per cent., owing to short measurements or to unmeasured increase of cultivation.

242. The assessable area all over the district at last settlement was returned as 232⅜ square miles. The Deputy Superintendent's estimate is that now it is not less than 800 square miles, of which 670 square miles have still to be surveyed.

243. A Deputy Collector was attached to the survey camp to settle boundary disputes of which there were 199. The Board's rules of procedure have been somewhat modified to suit the peculiar conditions of the country. It has been found necessary to classify the soil into irrigated 1st and 2nd class, dry, and *katil* (unterraced slope). Irrigation is easily recognised, owing to the construction of the fields; but as it is highly assessed, efforts may be made to conceal it if supervision is slack. The Settlement Officer has also issued rulings as to the status of occupants of land which was not measured at last settlement, and of which there is no record. Every piece of waste between fields of over 8 links width has been given a separate number, but as no one is in possession of these strips, the proprietor's column is left blank, which is a good rule, and overcomes many difficulties.

244. Inspections by the European officers of the party have been continuously made. Their check surveys and the independent *partal* lines amount to 93 and 325 linear miles respectively, whilst the check lines run by the inspectors amount to 828 miles. This gives an average of 6·4 miles of *partal* per square mile of survey. In eleven cases the survey had to be rejected and re-done, elsewhere the work proved good.

245. The season's out-turn is mapped on 1,996 sheets, on the scale of 32 inches = 1 mile, which has been found sufficiently large as a rule, and the maps show the true relative positions of all patches of cultivation. An index map (4-inch scale) to the cadastral survey has been prepared for each *patti*, which shows the relative positions of the villages to each other.

246. The physical and other difficulties encountered have been almost insuperable, one of the chief being to reconcile village boundaries in cultivation, for the theodolite stations could not be fixed on the boundaries, and accurate chain measurements over such hilly country are most difficult to make. The minor divisions of the villages called *odas* were insufficiently marked and were often changed or were shewn differently at different times. The Hindustani *amins* were most discontented on account of the cold, the high price of provisions and for other reasons: they threatened to strike in a body, and did actually do so at times in small numbers throughout the season, which caused much anxiety. The *pahâris* also worked unsatisfactorily. Progress was still further impeded by the unusual amount of rain during the field season.

247. The following is a list of the records to be supplied to the Settlement Officer:—

(1) *Khasra*, (2) Dispute List, (3) *Phant*, (4) *Muntakhib*, (5) *Khatauni* slips, (6) *Jamabandi*, (7) *Milan khasra*, (8) Crop statement, (9) Tracing in duplicate of the village map (on one the soils are coloured).

248. The traverse portion of the party was located at Naini Tal and the cadastral portion at Pauri, where the accommodation was most inadequate.

249. Colonel Sandeman acknowledges the co-operation of Mr. Partridge, the Senior Assistant Commissioner, and states that his own task has been considerably lightened by the assistance he has received on all occasions of difficulty, and by the clear instructions given as to procedure in making the record of rights.

250. During the absence of Colonel Sandeman on three months' privilege leave, the superintendence of the party devolved on Lieutenant Crichton, Officiating Deputy Superintendent, who, although with but little departmental experience, has carried out his duties quite satisfactorily. Mr. T. F. Freeman, surveyor, 4th grade, has supervised the operations of the Garhwal detachment throughout the field and recess seasons, and has overcome many difficulties which seemed almost insurmountable. Of Mr. Freeman, Colonel Sandeman thus writes: "He has now worked under my orders for the last eight years, and I have such a high opinion of his capacity as a surveyor, of his steadfastness and capacity for hard

work, that it has given me great pleasure to see him placed in independent charge of the detachment which is to continue the cadastral survey in Garhwal."

Survey of the Lansdowne Forest Reserve.

251. The survey of the forest reserve in the Lansdowne cantonment was sanctioned by the Government of India at an estimated cost of R3,500. According to the desire of the Conservator of Forests, Central Circle, North-West Provinces, the scale was fixed at 4 inches = 1 mile. The reserves which consist of several blocks with numerous patches of village cultivation dotted among them, are situated in *pattis* Sila and Ajmere of the Tala Salan *pargana* of district Garhwal, the new Lansdowne cantonment being a continuation of the reserves, although outside their limits.

252. The approximate area of the reserve, inclusive of village lands which have not been separated yet, is 34·7 square miles. The survey has cost R3,007, and the mileage rate is R86·10·6. The survey is based on 25 trigonometrically fixed points of the Garhwal topographical survey, supplemented by 16 new stations. The forest boundaries and those of the 117 scattered patches of cultivation have been traversed with the theodolite and subtense bar, the stations being fixed on the masonry pillars of the demarcation. The detail survey has been carefully made with the plane-table. The streams were all traversed and fixings made at all bends and prominent changes of slope along spurs and ridges. The details of village sites and cultivation limits which are outside the reserves, but are required to complete the map, will be obtained by reduction from the 32-inch cadastral survey maps. The heights of 769 plane-table fixings were obtained by the clinometer in addition to 41 trigonometrical heights, by which means the hills were contoured at 50 feet vertical intervals.

253. As there was no establishment in this party competent for work of this kind, sub-surveyors had to be obtained and trained by Lieutenant Crichton, who executed the triangulation and the contouring, and checked the detail work of these men. The survey was begun on 22nd February and field work closed on 20th June. The four final sheets cannot be completed till the cadastral survey has been made, but in the meantime a preliminary tracing is being prepared for the use of the Forest Department.

254. Lieutenant Crichton deserves credit for the manner in which he has executed the survey, which is his first piece of work of the kind, and for overcoming great difficulties, due to heat, sickness and desertions of menials, the frequency of which threatened to stop the survey at one time. The Deputy Superintendent personally checked four field sheets of different surveyors in the field and was satisfied with the accuracy of the work.

Miscellaneous work.

255. As the materials for the preparation of the Jhansi 2-inch standard sheets were not available during the season of 1889-90, they were accordingly left to be drawn during the past recess. Owing to lack of draftsmen the work is not out of hand yet, as ten sheets still remain to be drawn. The field sheets on the 8-inch scale of the Jhansi forests have been traced on bank post paper during the past recess. The scattered patches of forest have been so mapped that the number of sheets for reproduction has been reduced from 44 to 29. But as the patches of forest are not mapped in their respective geographical positions, an index map of all the forest blocks in their relative positions is under preparation on the 2-inch scale.

256. The 2-inch standard sheets of the Tarai survey, 14 in number, were completed and examined during the past season: a village by village statistical statement of the Tarai district has also been compiled from the materials of the surveys made since 1873.

257. The Kumaun Bhabar has been mapped on 30 sheets on the 4-inch scale, which will be available for the use of the Forest Officers, and will serve for reduction to the 1-inch scale.

258. The following junior Civilians went through a course of two months' instruction with the survey party:—

Messrs. R. W. Gillan, H. B. Bruce, J. H. Simpson, J. Mardon, W. H. Moreland, and H. K. Gracey, during November and December 1890; Messrs.

P. Harrison, W. R. G. Moir, B. Lindsay, O. G. Arthur, H. Duperneux, and C. E. Wild, during January and February 1891; and Messrs. L. H. Turner, P. Wyndham, H. T. Hoare, Rai Khushwakt Rai, and Syed Mohamed Mehdi, during March and April 1891. Owing to the limited survey establishment to be maintained in the North-West Provinces in future, the Deputy Superintendent has recommended that the instruction should in future be given at Roorkee College.*

ASSAM.

No. 6 Party.

Personnel.

Mr. E. C. Barrett, Officiating Deputy Superintendent, 2nd grade, in charge.
„ J. H. O'Donel, Surveyor, 3rd grade.
„ C. W. Wilson, Assistant Surveyor, 1st grade.
„ J. Smith, Assistant Surveyor, 2nd grade.
23 sub-surveyors and others.

Temporary Establishment.

75 inspectors, draftsmen, computers, etc.
70 field surveyors (imported).
68 *mandals* and candidates (local).

259. This party, of the strength noted in the margin, left its recess quarters at Shillong on the 20th October 1890. Field work was started in the Assam valley and in district Sylhet during the first week of November 1890. Field operations were continued till the 18th May 1891, when the office establishment returned to Shillong.

260. Cadastral operations in the Assam valley were carried on in districts Nowgong, Kamrup and Darrang, and comprised the survey of detached blocks of fairly well cultivated land adjoining the tracts that had been surveyed by the party in those districts in seasons 1883 to 1888. The field-to-field survey was carried on, as in previous years, by local and imported *amins*, but it was not found possible to maintain anything like the same proportion between the different agencies employed, the local administration having found it impossible to allot more than 50 men for survey work owing to the large number of *mandals* (village headmen) required as census enumerators. The local and Bengali *amins* wrote up their own village records, but it was found necessary, as in former years, to allow each Hindustani *amin* a writer to assist him in preparing the Bengali records. In *pargana* Partabgarh (Sylhet), Bengali *amins* only were employed in field-to-field survey, and Hindustani *amins* and sub-surveyors in the survey of grants.

261. A training school was established at Mangaldai on the 1st of October 1890. Instruction in practical surveying was given to 57 *mandals*, of whom 50 were retained for work; and to 49 candidates, 8 of whom were considered fit for work. The *mandals* worked satisfactorily as long as operations were confined to district Nowgong, but great difficulty was experienced in persuading those who did not belong to Kamrup to enter that district, which has an evil reputation on account of the prevalence of the disease known as *kala ajar*; no less than 7 *mandals* threw up appointments rather than take up work there. The *mandals* during the whole period of their stay with the survey party received the pay of their respective grades from their districts, and they were paid, in addition for the survey work they did, at one-third the contract rates allowed to Hindustanis. Candidates were paid at two-thirds of the same rates. The average areas accomplished by each of the different agencies employed in the field survey are as follows:—

	Acres.
By Hindustani *amins*	3,470
„ Bengali „	2,737
„ *Mandals* (old)	2,469
„ „ (new)	1,100
„ Candidates (old)	2,924
„ „ new	1,150

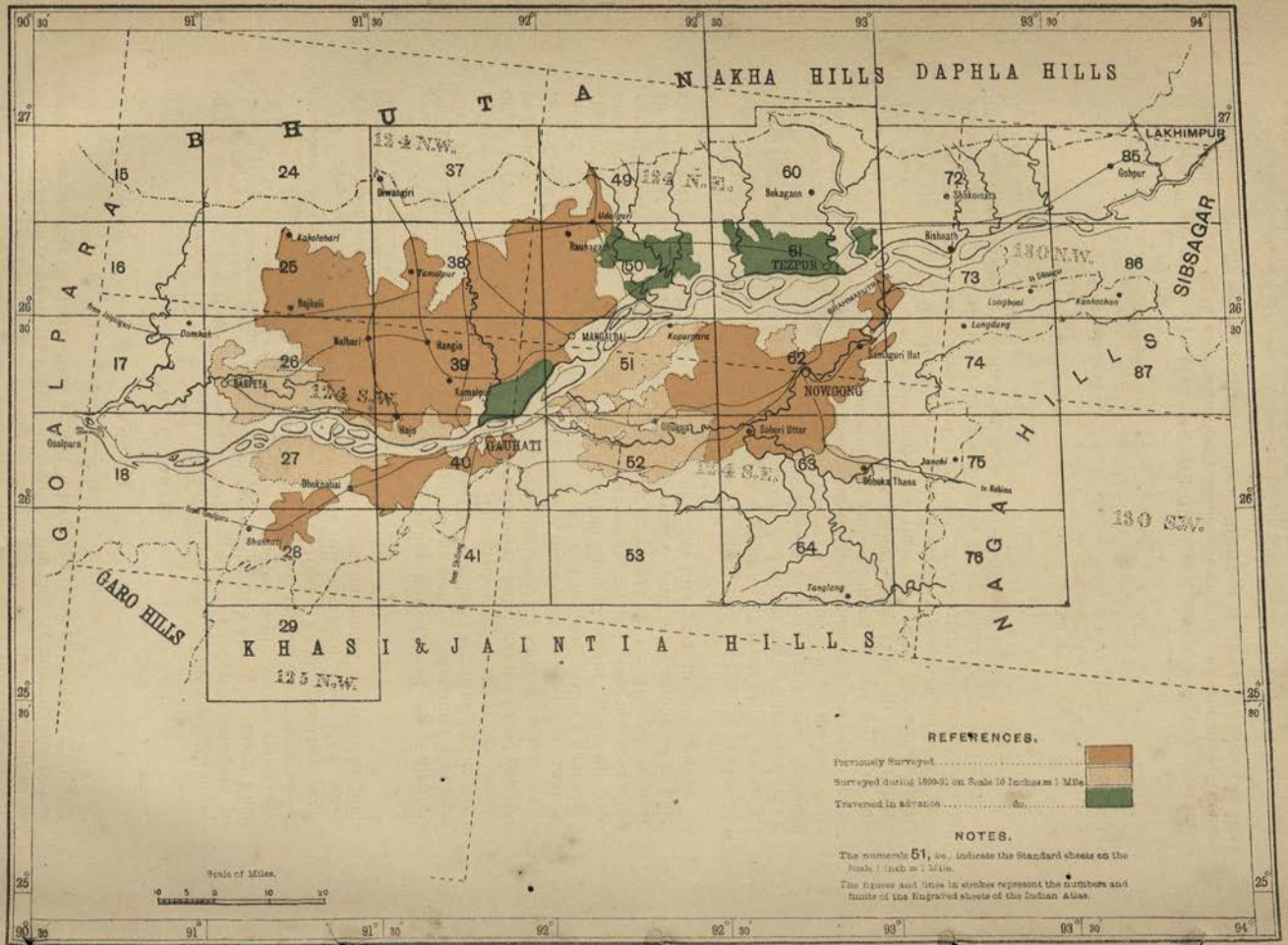
262. Traverse survey was carried on in districts Kamrup, Nowgong, Darrang, and Sylhet. The work was particularly arduous owing to the operations being extended over very widely scattered areas. Kamrup is the only district in the

* Colonel Sandeman thus reports of his Assistants:—Mr. A. W. Smart, in his conduct of the Rampur survey, has proved his capacity, resource and discretion. Messrs. N. Bedford, W. V. Skilling, and J. H. Murphy have all done their best. Of the native surveyors the following are deserving of mention:—Badr Pershad, Nidha Lall, Golam Gaus, Joala Pershad, Dhanpat Rai, Ganga Pershad, Waris Ali, Abdul Hadi, Parnia Nand, Ram Sohai, Salamat Ali, Kurbat Ali, Dilshad Ali.

ASSAM SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTS. KAMRUP, DARRANG, & NOWGONG.

No. 6 PARTY.



ASSAM SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT SYLHET.

No. 6 PARTY.

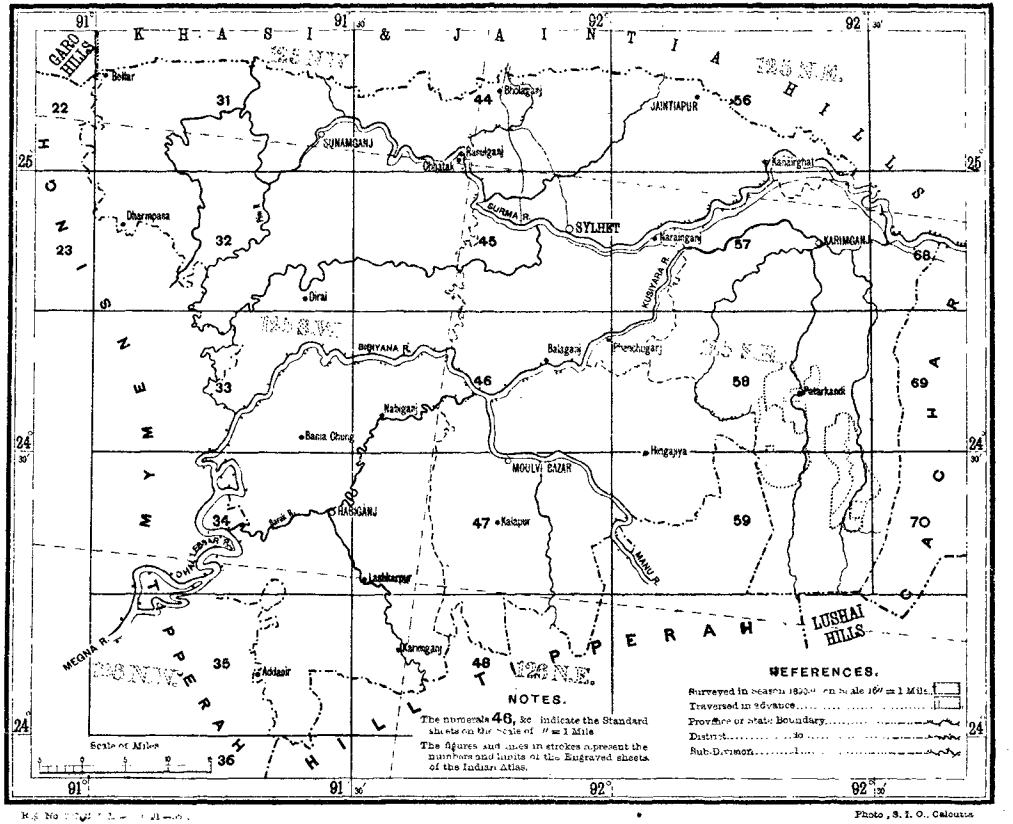


Photo., S. I. O., Calcutta

Assam valley in which the unit known as the "village" existed prior to the arrival of the survey party. These villages varied in size from plots a few acres in area to large tracts several square miles in extent. To ensure something like uniformity in size, as many of the smaller villages as could be plotted on to a cadastral sheet were amalgamated, while the larger villages were sub-divided into blocks, averaging about a square mile in area. Each of these blocks retains the name of the village of which it forms a part, and receives a distinguishing number. In districts Nowgong and Darrang the *mauzas* have been cut up into village blocks, averaging about a square mile each. In *pargana* Partabgarh small contiguous villages have been amalgamated after the manner of Kamrup.

263. The season's out-turn of traverse and cadastral survey is given in the following statement :—

Districts.	Traverse Survey.			Cadastral Survey.		
	Number of *mauzas*.	Number of villages.	Area in square miles.	Number of villages.	Number of fields.	Area in square miles.
Nowgong . .	12	309	270·23	501	73,752	413·95
Kamrup . .	16	485	393·52	451	88,644	364·60
Darrang . .	16	248	235·79	2	336	2·45
Sylhet . .	1	124	116·46	46	18,398	46·92
TOTAL .	45	1,166	1,016·00	1,000	181,130	827·92

The area completed contains the following tea and other estates :—

Districts.	Grants.				*Lakhiraj* (rent-free).		*Nisf-Khiraj* (half-rent).		*Ilam* (temporarily settled.)	
	Fee simple.		30 years' lease.							
	No.	Area in acres.	No.	Area in acres.	No.	Area in acres.	No.	Area in acres.	No.	Area in acres.
Nowgong . . .	2	407·95	2	407·60	...	...	1	2·14	...	...
Kamrup	...	...	1	1,000·00	21	3,604·67	126	17,313·39	...	...
Pargana Partabgarh (Sylhet)	...	...	20	16,471·00	...	...	...	...	10	552·35
TOTAL .	2	407·95	23	17,878·60	21	3,604·67	127	17,315·53	10	552·35

264. The cadastral work has been tested by 2,984 linear miles of check survey run through it by European and native agencies, giving on an average 3·60 linear miles of check to the square mile of detail survey. Village sites were tested by a re-survey of about ten per cent. of the area of each site. The entries in the records of 54,758 fields were tested in the presence of the *rayats* concerned by European officers and inspectors ; and the sub-deputy collectors and *munsarims* of the Settlement Department were occupied throughout the field season in checking the *khasra* entries. The traverse measurements have been tested by connections with five Great Trigonometrical and nine topographical survey stations, and the angular work by observations for azimuth taken at 94 stations.

265. Twelve revision squads, each composed of a survey *amin* and a settlement *munsarim*, were employed in district Sibságar from the 1st of November 1890 to the 1st of March 1891, in enquiring into objections raised by the *rayats* against the disposition of their holdings by the survey of the previous season. The total number of objections raised, all of which have been adjusted, was 5,434 against 10,409 of last year. Of the 599 villages representing the out-turn of 1889-90, no less than 289 villages or nearly half the total number were finally passed as surveyed, which shows that the work of the year was particularly good.

266. The season's operations, both in Sylhet and the Assam valley, were marked by the absence of obstruction on the part of the *rayats*. In the

villages close to Barpeta, in district Kamrup, the *rayats* refused for a time to assist the surveyors, but a reference to the Deputy Commissioner speedily set matters right.

267. The field season was unusually unhealthy, especially in Sylhet, where the establishment suffered very much from malarial fever. Of the five traverse sub-surveyors who were sent into *pargana* Partabgarh, two had to be invalided before the close of the field season, one dying shortly after arriving at his home. In the Assam valley a traverse sub-surveyor died of cholera in April.

268. The season's out-turn has been mapped on 1,067 sheets. The settlement officer has been provided with tracings of all the cadastral sheets and with the original *khasra* and *dag chitta* (village record) books of the area completed in the Assam valley. He has also been furnished with separate tracings of all *nisf-khiraj*, *lakhiraj*, and other estates. Tracings of the cadastral maps and the original village records of the area completed in *pargana* Partabgarh have been forwarded to the Deputy Commissioner of Sylhet.

269. The Hon'ble J. W. Quinton, C.S.I., the late Chief Commissioner of Assam, inspected the field offices of the party at Mangaldai on the 6th February 1891.

270. The Deputy Commissioners of Kamrup and Darrang, and the subdivisional officers of Karimganj in Sylhet, afforded the members of the survey party every necessary assistance. The Deputy Superintendent expresses himself under particular obligations to Mr. Gordon, the Deputy Commissioner of Kamrup, for the effectual manner in which he overcame the tendency to obstruction on the part of certain *rayats* of the Barpeta sub-division.

271. The Deputy Surveyor-General, Revenue Branch, inspected the party during the month of September and thoroughly scrutinised the books and records. He was well satisfied with all that he saw. Mr. Barrett deserves much credit for the way in which, through good management, he has year after year succeeded in gradually reducing the cost rate of the work until now it may be considered to be as low as it is possible to make it without running the risk of impairing the accuracy.*

THONGWA AND AMHERST DISTRICTS, LOWER BURMA.

No. 7 PARTY.

272. This party was employed during the season in both the Thongwa and Amherst districts. The traverse section left Rangoon on 9th November, two sub-surveyors being sent off to complete the boundary survey remaining in the Kyonton circle of the Thongwa district, and the main body to continue the work which had been begun the year before in the Amherst district. The two cadastral sections left Rangoon on 3rd December, and all returned to recess quarters between the 15th and 18th of May 1891.

Personnel.

Mr. C. Wood, Officiating Deputy Superintendent, 4th grade, in charge from 1st December 1890.
Mr. A. E. Spring, Officiating Assistant Superintendent, 1st grade, from 17th March 1891.
Mr. H. R. Littlewood, Officiating Assistant Superintendent, 1st grade, up to 27th June 1891.
Mr. G. W. Jarbo, Surveyor, 4th grade.
Mr. J. S. Swiney, Surveyor, 4th grade.
Mr. F. B. Powell, Assistant Surveyor, 2nd grade.
Mr. J. A. T. Haddock, Assistant Surveyor, 2nd grade.
21 sub-surveyors and others.

Temporary Establishment.

61 inspectors, draftsmen, computers, &c.
81 field surveyors.

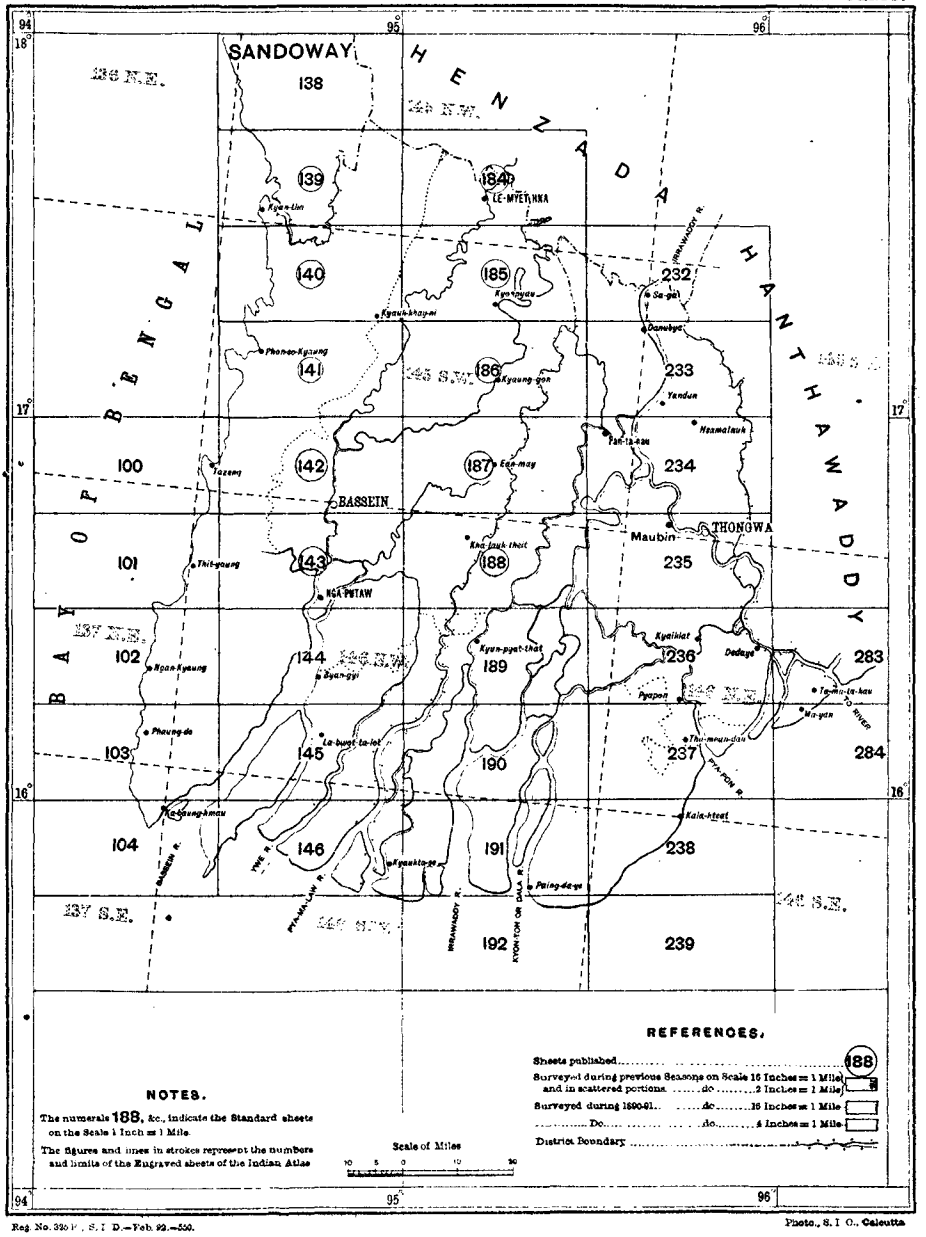
273. The work in Thongwa comprised the following:—(1) the cadastral survey of 320 square miles in the Tawhla, Tomayan, Kyonton, and Taungbogyi circles of the Dedaye and Pyapon townships; (2) the interior traverse survey of 106 square miles, of which the outer boundary was formed by part of a main circuit executed in 1889-90; (3) the detail survey, on the 4-inch scale, of 164 square miles in the western portion of the Kyonton circle, based on 93 square miles of the traverse work referred to under head (2), and of 59 square miles executed in 1889-90. With regard to this last portion of the work, it may be men-

* Mr. Barrett again brings the excellent services of his senior assistant, Mr. J. H. O'Donel, prominently to notice. He commends Mr. C. W. Wilson for the manner in which he has brought up the work of the traverse section, and favourably mentions Sakhawat Hossein, Khursed Hossein, Dilawar Khan, and Mohamed Ismail, sub-surveyors; Krishnaji Mahadeo Raj and Gunga Ram, computers; and Golam Hyder draftsman, of the Professional Establishment; and Sitanath Chuckerbutty, Jhuni Lal, Harakhnarain, and Bahadur Sing of the Cadastral Establishment

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTS. BASSEIN & THONGWA.

No. 7 PARTY.


SANDOWAY
HENZADA
BASSEIN
THONGWA
Maubin
LE-MYETHNA
Kyun-lin
Kyauk-khay-ni
Phoon-so-Kyaung
Kyaung-gon
Tazeng
Thit-young
NGA PUTAW
Kyan-gyi
Phaung-de
Ka-kyaung-hmau
Kyaukta-ge
Paing-da-ye
Kyun-pyat-that
Kyaukkat
Pyapon
Thu-maun-daw
Kala-htwet
Yandun
Hnamalauk
Danubya
Se-gal
Ma-gan
Dedaye
Kyailklat
Pan-la-aau
Ka-lauk-thoit
Ka-lauk-thoit
Ka-lauk-thoit

tioned that, partly from want of provision in the budget, but chiefly because cultivation had not made much head in that tract, the Financial Commissioner decided that cadastral operations should not be extended into the western portion of the Kyonton circle, and directed that the traverse work already done therein should be utilised and extended sufficiently to enable a 4-inch detail survey of the tract to be executed.

274. On the party commencing field operations, a larger proportion of cultivation than was expected was met with, and the officer in charge of the survey camp found the country opening up so fast that he expected ere long to hear that a 16-inch survey was ordered. This expectation has already been realised; and as the Local Government has given orders for its execution by the supplementary survey, that department has been allowed to take a transcript of all the traverse data, and a tracing from the 4-inch survey of the tract.

275. This season's work has brought to a close the survey of all the tracts assigned for survey in Thongwa, extending over 2,910 square miles, which has been done at a total cost of Rs. 580,769. It may be also mentioned here that, as the Settlement Department was anxious that its operations in Thongwa should be completed during the first half of the financial year 1891-92, arrangements were made to supply preliminary 16-inch tracings as soon as a sufficient number of villages had been surveyed, to admit of the men who marked out the different holdings and who followed close on the survey, to be themselves followed up by the revision survey, where necessary, with the least possible delay. In this way the work was advanced; and all the final village maps and area statements were in the hands of the Settlement Department by the third week in August.

276. In the Amherst district, the traverse or boundary survey of 815 square miles was completed, while the cadastral survey embraced an area of 408 square miles, as against an expected out-turn (*vide* para. 291 of the Annual Report for 1889-90) of 630 and 225 miles, respectively. The former class of work covers all the tracts that had been assigned for survey in the Wagaru, Zaya, Bilugyun, Gyaing-Ataran, and Haungtharaw townships, and about one-half of that in the Gyaing-Salween and Martaban townships. The cadastral section has completed all that had been assigned for 16-inch survey in the two first named townships, and all but 25 square miles of the Bilugyun township.

277. All the traverse stations were marked in the usual way, and measures taken, as detailed in para. 283 of the Report for 1889-90, for their protection. It may be mentioned that the *kyedangyis* (head watchmen) did not in all cases show their willingness either to go round and see the stations or to sign receipts for them; but it is a satisfaction to know that this class of underlings is fast giving place to the *ywathugyis* (minor village revenue officials) who are being appointed in Lower Burma. The preparation of census returns, and collection of revenue were, in some instances, adduced by *thugyis* (revenue officers of circles) as excuses for not helping in the matter of enforcing the *kyedangyis*, or of going out of their way to show their boundaries, where not demarcated.

278. The angular results of the season's traverse survey have been checked by star observations for azimuth at 105 stations, and the linear results were checked by connection with 9 stations of the Trigonometrical Survey: in both cases, the smallness of the corrections (*viz.*, 4 seconds per angle and 3 feet per mile) shows that the work was very satisfactorily done. The detail survey on the 4-inch scale was checked by five miles of *partal* and numerous *in situ* fixings; while that on the 16-inch scale was checked by 1,612 miles of *partal*, of which 320 miles were run by Europeans.

279. The following statement shows the results of the season's work, both as regards traverse and detail survey:—

District.	Traverse Survey.		Cadastral Survey, 16 inches = 1 mile.			Detail Survey, 4 inches = 1 mile.	
	Number of kwins.	Area in square miles.	Number of kwins.	Number of fields.	Area in square miles.	Number of kwins.	Area in square miles.
Thongwa . . .	43	106	175	1,33,000	320	71	164
Amherst . . .	594	815	308	3,70,632	408	...	...

280. The area surveyed in each district is classified as below:—

Classification.	Thongwa.		Amherst.	Total.
	16-inch scale.	4-inch scale.	16-inch scale.	
	Square miles.	Square miles.	Square miles.	Square miles.
Cultivation	141·5	40	265·5	447
Jungle and waste, including water	178·5	124	142·5	445
Total .	320·0	164	408·0	892

It will be seen that the cultivation comprises half the total area surveyed; and that while the proportion of cultivation to jungle (on the 16-inch scale) in Thongwa is about 3 to 4, or somewhat less than it was in 1889-90, it is over 7½ to 4 in Amherst. The average size of the fields this year in Thongwa is 0·95 of an acre against 0·78 in the year before; while in Amherst it is only 0·48 of an acre. The small size of the field and the greater proportion of cultivated lands to jungle in Amherst both tend to increase the cost rate; the first because the smaller the field the slower the progress, and the second because the field surveyors are paid four times as much for the cultivated lands as for the jungle tracts.

281. The season's detail area is mapped on 1,016 sheets of the 16-inch and 14 of the 4-inch survey. Of the 1,458 sheets of the past season, over 900 have already been sent to Calcutta for printing: the remainder are well in hand, and it is hoped that most of them, if not all, will be despatched before the party next takes the field. The unusually large number of these sheets—about half as many again as in previous years—has seriously taxed the energies of the party, more especially as Mr. Littlewood had to be transferred to take charge of No. 8 party during Mr. Patterson's absence on leave, and so his valuable assistance was lost for a period of three months during the recess. The 2-inch sheets of the entire Thongwa survey, prepared for reduction to the standard 1-inch scale, have also been satisfactorily pushed on; but this work, too, has been unusually heavy owing to the party having been ordered to complete all the sections up to margin, by incorporating the results of recent surveys with those of previous seasons, so as to render the maps as complete as possible. The drawing of nearly the whole of the sections has been so far advanced as to warrant their completion during the next three or four months, when the 2-inch mapping of the Amherst district will be taken up. It having been finally decided that the sub-division of certain *kwins* which were surveyed in 1888-89-90, referred to in paragraph 286 of last year's report, was unnecessary, no extra drawing on this account had to be done.

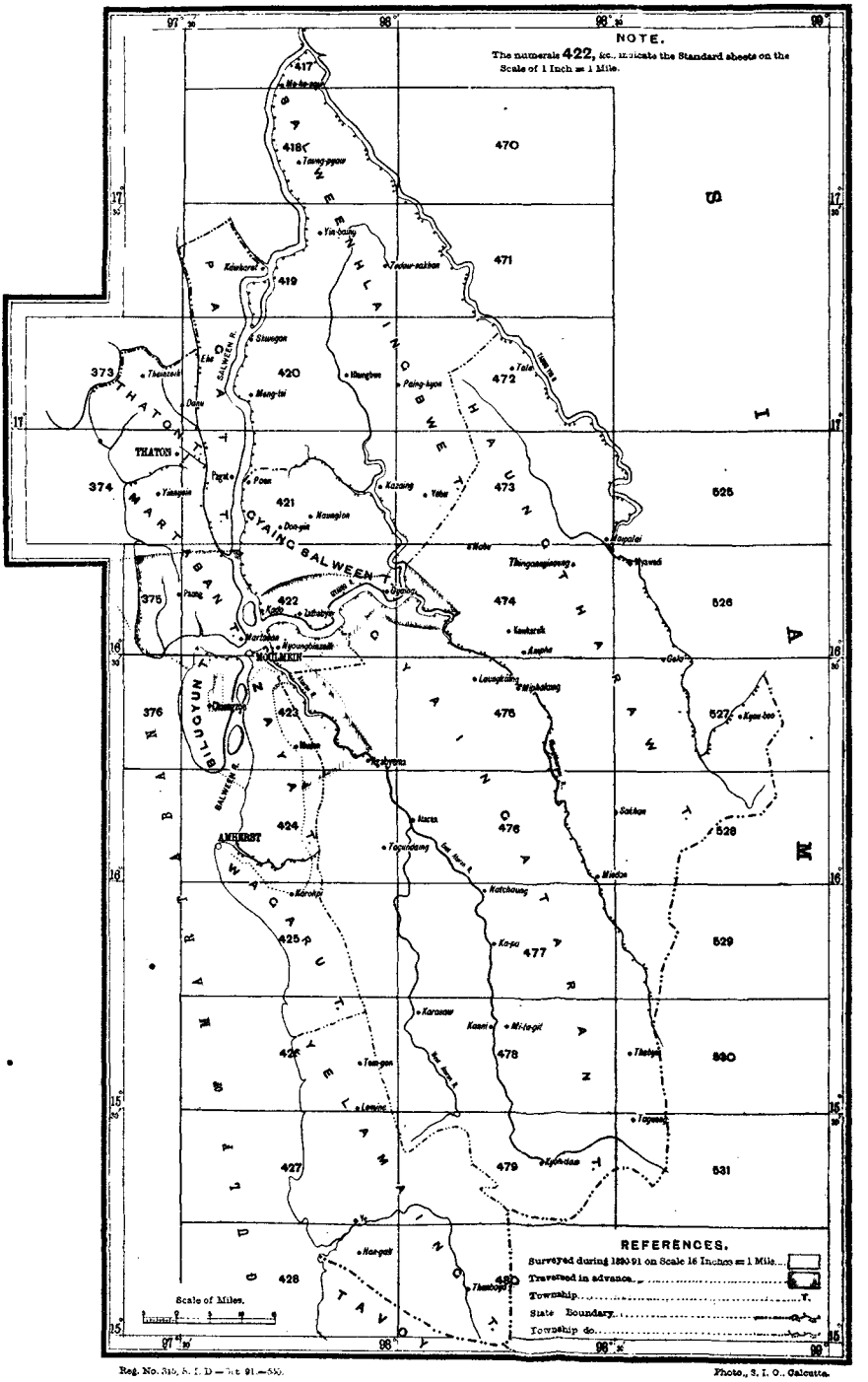
282. The records of the present season's work have been indexed and bound; and nearly the whole of those appertaining to Thongwa, since its survey was taken up, will shortly be despatched to the head-quarters office for final deposit.

283. The scheme for the employment of Burmans and Karens as field surveyors has worked satisfactorily during the year. Owing to a diminished budget, employment could only be given in the party to 49 of the 69 men mentioned in para. 288 of the report of the previous year; but similar work was found for 16 others with the supplementary survey: one man out of the 69 did not rejoin, having secured a post as *thugyi*, and three others were found too weak for field work and were allowed to return home. Of the 28 pupils of 1889-90, the party gave field work to seven men, and found employment in the supplementary survey for five more; whilst others were given office work. Of the 49 old men who were given employment, one had to retire from the field on account of sickness, but all the others, with only a single exception, secured a bonus, while two of the pupils of the previous year also qualified for a small bonus. The rate of progress, and consequently the amount of earnings and bonus, shows an advance

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT AMHERST.

No. 7 PARTY.



Reg. No. 310, A. I. D.—Oct. 91.—550.

Photo., S. I. O., Calcutta.

over the previous year: the average earnings this year being R185, as against R168 and R114 in the two preceding years, respectively.

284. Of the 728 square miles surveyed cadastrally, 54 Burmans have contributed 404 square miles, and 27 Hindustanis 324 square miles besides 164 square miles of 4-inch work: this gives the average out-turn of the Burman as four-sevenths of that of the Hindustani against three-sevenths in 1889-90. This is the fifth year of service for some of the men, and two inspectors and eighteen field surveyors have now qualified for the certificate and deferred pay which has been accumulating to their credit in the Savings Bank. With the certificate, under Mr. Bridges' scheme, dated 26th February 1886, they would, *cæteris paribus*, be entitled to "the first claim to appointment as *teiksayès*, *thugyis*, or inspectors of supplementary survey, and might also receive higher appointments in the survey, and appointments as superintendents of supplementary survey." The usual report on the working of this project was submitted some months ago, but final orders for the issue of the certificates and deferred pay have not yet been received. In order to give a real value to the certificate, and thus to allay some fears which seem to be getting possession of the men's minds that the certificate is worth much less than they were led to expect, from the fact that the market is becoming overstocked with men trained in the supplementary surveys, the executive officer specially recommended two of his most deserving men for posts as settlement inspectors, and it is hoped that his recommendations will be acted upon; for otherwise, in his opinion, some defection in their ranks will be sure to ensue; as the Burman values the possession of immediate advantages above prospective higher advantages in which he believes there may be some uncertainty, and he is therefore ready to transfer himself to any new employer who will offer him a few rupees a month more, even at the risk of eventual loss. At the close of last field season, the number of men on the rolls and their length of service were as below:—

Of 2 years' service	. . . . .	7 men.
„ 3 „	. . . . .	18 „
„ 4 „	. . . . .	26 „
„ 5 „	. . . . .	18 „

285. The field office of the party was inspected at Moulmein in April by the Deputy Surveyor-General in charge Revenue Branch, who was thoroughly satisfied with the progress of the work, and the general state of the books and records of the party.

286. During the ensuing season, the operations of this party will be extended to Tavoy and Mergui. At a conference held at Rangoon on the 25th of April 1891, at which the Financial Commissioner and the Deputy Surveyor-General were present, it was decided that all the cultivated and culturable lands in these districts should be surveyed by the party in addition to the work in Amherst: the cultivated areas had been "notoriously much understated" at 200 square miles, and it was thought that by a small addition to the strength of the party it might be able to furnish "correct areas (and possibly new maps) before June 1892 in time to allow of revised assessments coming into force in 1892-93." It is expected that the work will turn out a far greater undertaking than was at first thought, but nothing will be wanting to endeavour to secure the end in view. In addition to the foregoing, traverse work will be carried on in Amherst so as to complete the Gyaing-Salween, Pagat, and Martaban townships, and as much as possible in Thaton also; while the cadastral operations will comprise the survey in detail of the 572 square miles traversed in advance during the year under report, in which, however, about 100 miles of hilly ground will be done on the 2-inch scale.*

* The executive officer referring to the work of his assistants says:—Mr. Littlewood's help is cordially acknowledged, and he is commended as "very judicious in his management of natives, and combining sound judgment and a thorough knowledge of cadastral work with remarkable evenness of temper." Mr. Jarbo is "an excellent assistant, and to his persistent and methodical efforts is due the large out-turn of traverse work." Mr. Swiney too is a "very capable assistant," with a thorough practical knowledge both of traverse and cadastral operations. Messrs. F. B. Powell and J. A. T. Haddock are both well spoken of as hardworking and useful assistants. The following members of the native establishment have done well:—Nand Lall Chatterjee, Ishan Chander Ghosal, Shoshi Bhushan Ghosal and Preonath Banerjee, computers; Abren, Faiz Baksh, Mahomed Umar, Mahbub Ali and Mahomed Ali, sub-surveyors; Wahid Ali, draftsman, Mahtab Khan, supervisor; Maung Hpo Ka and Do Khine, writers; Maung Chein, Maung Hpo Thin, Lal Bahadur and Karim Baksh, inspectors.

ORISSA.

No. 8 Party.

287. This party resumed operations in the districts of Pooree and Cuttack, and was under the charge of Mr. W. H. Patterson throughout the field season and up to the 10th July, when Mr. H. R. Littlewood was appointed to the charge, Mr. Patterson being placed on special duty before taking privilege leave. The party was divided into three sections as detailed in the margin, two being for cadastral operations, and the third for traverse work.

Personnel.

Mr. W. H. Patterson, Officiating Deputy Superintendent, 3rd grade, in charge, up to 10th July.
Mr. H. R. Littlewood, Officiating Assistant Superintendent, 1st grade, in charge, from 11th July.

Pooree Section.

Mr. R. C. Ewing, Surveyor, 4th grade.
„ E. F. Berkeley, Assistant Surveyor, 2nd grade.
65 computers, draftsmen and *mohurrirs*.
28 inspectors and instructors.
229 field surveyors (*patwaris* and other local men).

Cuttack Section.

Mr. S. O. Madras, Surveyor, 4th grade.
„ J. B. Barker, Assistant Surveyor, 2nd grade.
56 computers, draftsmen and *mohurrirs*.
24 inspectors and instructors.
212 field surveyors (*patwaris* and other local men).

Pooree and Cuttack Traverse Section.

Mr. C. S. Kraal, Assistant Surveyor, 1st grade.
„ C. S. Gasper, Assistant Surveyor, 3rd grade.
22 sub-surveyors.
12 computers and draftsmen.

288. The traverse section commenced operations in both districts simultaneously, leaving recess quarters on the 10th November 1890, and continuing work till the 6th July 1891. The camp office under Mr. Kraal returned to recess quarters on the 22nd June, leaving a detachment of 13 sub-surveyors and their squads under the supervision of Mr. Gasper to complete the required area.

289. The cadastral section employed in Pooree commenced field work on the 6th December 1890, and returned to recess quarters on the 17th June 1891, leaving some inspectors till the 9th July to complete the final *partals* and the checking of *khasra* entries.

290. The third section left recess quarters on the 24th November 1890, and continued in the field till the 1st July 1891, when the camp office returned to Cuttack, leaving a portion of the field establishment at work till the 15th of that month.

Survey of Pooree District.

291. Traverse operations were carried on over an area of 481 square miles, of which 313 square miles have been surveyed in detail, leaving 168 square miles traversed in advance for next season. In addition to this 313 square miles of detail survey, 53 square miles, which had been traversed in 1889-90, were also completed. The areas traversed and cadastrally surveyed are detailed in the following statement:—

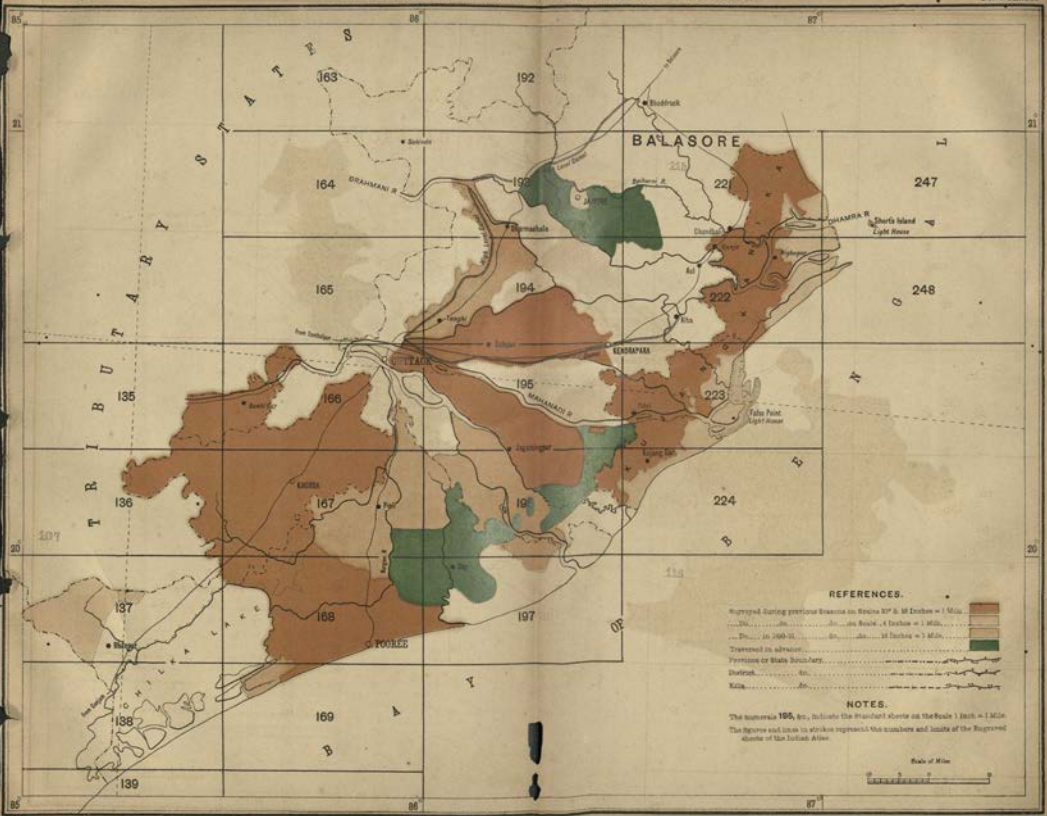
District.	Cadastral Survey, 16 inches = 1 mile.			Traverse Survey.			
	Number of villages.	Number of fields.	Area in square miles.	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Pooree . .	818	667,487	366	1,108	676	12,516	480·68

292. The number of linear miles traversed was 2,049, contained in 3 main and 18 sub-circuits. The average size of the field is 0·35 of an acre, calculated on the total, after excluding sand waste in *parganas* Andhari and Manikpatna. The unit of measurement was the field as described in para. 315 of the General Report for last year. The *kittas* within the fields, formed by sub-dividing ridges for the convenience of agriculture, were also surveyed and amounted to 10,20,984, which gives a percentage of 1·5 *kittas* to each field. The accuracy of the angular work was tested by 65 observations for azimuth. Permanent marks

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY OF ORISSA, DISTS. CUTTACK & POOREE.

No. 8 PARTY.


BALASORE
BAY OF BENGAL
TRIBUTARY STATES
CHILKA LAKE
BRAHMANI R
MAHANADI R
KENDRAPARA
JAJPUR
KHURDA
PURI
POOREE
Bhadruck
Balasore
Dhamra R
Short's Island Light House
Falso Point Light House
Jagannagar
Kujang Sub.
Pipli
Pooree
Khurda
Jajpur
Kendrapara
Dhamra
Chandbali
Bhuvaneshwar
Pipli
Pooree
Satpara
Nimapara
Kujang
Jagannagar
Kendrapara
Jajpur
Khurda
Pooree
Balasore
Bhadruck
Dhamra
Chandbali
Bhuvaneshwar

were embedded at 12,516 points; 7,271 of these were stones and 5,245 baked clay-cylinders, which have been used so as to reduce the cost, the stones being placed at trijunction points and satellite stations, the clay-cylinders marking all other theodolite stations; this procedure was adopted from March 1891. The traverse survey was connected with the survey of Khurda, made in 1875-78, the stations of which, with very few exceptions, were identified and incorporated with the season's work.

293. Training schools, for instruction in field surveying to *patwaris* and other local men, were established at twelve centres in the Pooree district and at two centres in Balasore. In the former district the schools were kept open from the 5th November 1890 to 15th June 1891. Five hundred and sixteen men were trained, but only 267 of the number could be employed; the remainder will doubtless be given an opportunity for employment next season, when the villages in which they reside come under survey operations. The schools in Balasore remained open from the 18th April to the 15th August, when, owing to the impracticability of outdoor training during the rains, they were, with the approval of the settlement officer, closed. Eighty-seven men were trained in this district, and will in all probability be employed in cadastral work next season. An average number of 229 local *amins* were employed monthly on field surveying and *khasra* writing under the supervision of four head inspectors (Hindustanis), eleven Hindustani and eleven Uriya inspectors The average daily out-turn of work performed by newly trained *amins* was four acres, while the men of one or two years' experience did 9·5 acres; this is much below the average out-turn to be obtained from a second-rate Hindustani *amin*. The *khasra* writing was, as a rule, completed by the *amin* or *patwari* who surveyed the village: 44,676 *khasra* entries were checked by European assistants, and 125,113 by native inspectors, which gives a percentage of 25 on the total number of fields surveyed.

294. The area cadastrally surveyed by this section has been mapped on 931 sheets. It was tested by 1,224 linear miles of check survey, of which 394 miles were measured by Europeans and 830 miles by native inspectors. The records and tracings of 443 villages had been supplied to the Settlement Department up to the 30th September, and there is every reason for supposing that the remaining villages will be furnished in proper time, if the boundary disputes which are about 150 in number, are settled.

295. The drawing of the standard sheets on the 2-inch scale has been commenced, six sheets have been projected, and the pentagraphing and mapping of details in each of the sheets is in progress.

Survey of Cuttack District.

296. As no demarcation was ready in the high-level canal tract, traverse operations could not be carried on in continuation of the portion traversed in advance during the past season. Work was commenced to the south of the district, which adjoins the portion being traversed in Pooree. In April, a detachment was sent to the north of the district to traverse the area that had been demarcated near Jajpur. The demarcation by Babu Damodar Patnaik, Assistant Settlement Officer, in the tracts traversed during the season, was very good, and no difficulty was experienced by the sub-surveyors in tracing the boundary, as prominent mud pillars, 3½ feet in height, were erected at all the bends of boundaries; trijunctions of villages were also so marked as to be readily recognisable. Of the area traversed, during the season *viz.*, 500 square miles, 202 square miles in addition to the 119 square miles prepared in advance during 1889-90, have been surveyed in detail, leaving a balance of 298 square miles traversed in advance for next season. About $\frac{5}{6}$ths of the survey stations of 1877-78 were identified and incorporated with the work of the current season.

297. Permanent marks were embedded at 13,039 stations; of these 5,975 were stones fixed at trijunctions of villages and satellite stations; and 7,064 were baked clay-cylinders to mark other theodolite stations. In addition, the permanent marking of 1,292 stations, in the tract mentioned in paragraph 320 of the General Report for the previous year as having been left unfinished, owing to the early setting in of the rains, was completed. Owing to the difficulty this season of transporting stones when the high-level canal was closed for repairs, the permanent marking of the stations in a portion of country about 56 square miles in

area and containing 119 villages was obliged to be left unfinished: clay-cylinders have been embedded at every station, and early during the ensuing season, stones will be substituted at all necessary points. Azimuths were observed at 90 stations as a check on the angular work.

298. The out-turn of area traversed and surveyed cadastrally is tabulated below:—

District.	Cadastral Survey, 16 inches = 1 mile.			Traverse Survey.			
	Number of villages.	Number of fields.	Area in square miles.	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Cuttack . .	863	485,691	321·23	1,242	542	13,039	500 59

The average size of the field is 0·42 of an acre. The number of *kittas* surveyed amounted to 12,15,496, of an average size of 0·16 of an acre. The average number of *kittas* to each field is 2·5. The detail work was tested by 1,543 linear miles of check survey, 345 of which were surveyed by the European assistants and 1,198 miles by native inspectors.

299. Training schools for the instruction, in field surveying and plotting, of *kanungos*, *patwaris* and other local men were established at ten convenient centres; these were supervised by seven Uriya instructors, *i.e.*, three inspectors and four selected *amins*: nine *kanungos*, 58 *patwaris* and 288 local men, making a total of 355, were trained. During the season, 58 *patwaris* and 164 newly trained men were employed, and in addition 6 *patwaris* and 118 *amins*, who had been previously trained in Banki, Kujang and Kanika, were also employed. The average number of all classes employed monthly, after making allowances for absentees, was 212. The field surveying was done by local agency alone, supervised by two Hindustani head inspectors and 24 Uriya inspectors. The average daily out-turn by newly trained men was two acres, and that by previously trained *amins* five acres. The comparative statement given below shows the increased expenditure incurred on account of coolie labour, consequent on the employment of newly trained indigenous agency; this materially affects the cost rate:—

	Number of acres.	Time employed, days.	Contract earning.	Cost of coolie labour.	Average daily out-turn, in acres.	Rate per acre.
			R a. p.	R a. p.		R a. p.
Patwari . . .	183	47	...	14 11 0	3·9	0 1 3
2nd rate Hindustani *Amin.*	183	12	5 7 10	3 12 0	15·	0 0 9
Local *Amin* . .	117	32	3 9 3	10 0 0	3·7	0 1 9
2nd rate Hindustani *Amin.*	117	8	3 9 3	2 8 0	15·	0 0 9

The *khanapuri* or record-of-rights was in every instance completed by the same *amin* or *patwari* that surveyed the village; 18,362 *khasra* entries were checked by European assistants and 130,887 by native inspectors, which gives a percentage of 31 on the total number of fields surveyed.

300. The area surveyed cadastrally during the season has been mapped on 979 sheets. The records and tracings of 347 villages have been supplied to the Settlement Department up to the 30th September. Boundary disputes on 103 villages still remain unsettled, and these prevent the adjoining villages from being completed and the records supplied to the Settlement Department. The projection of six standard sheets on the 2-inch scale has been completed; the reduction by pentagraph of details from the 16-inch scale plans and the mapping is in progress.

Survey of the Wards' Estate of Killa Kujang, Cuttack.

301. The records of the 15 villages mentioned in paragraph 300 of the General Report for 1889-90, as remaining to be supplied to the Settlement Department, have been completed and made over.

As revisions are now being received, the records of this estate, which were ready for despatch to the Head-Quarters Office, Calcutta, have been necessarily retained.

Survey of the Wards' Estate of Kanika, Orissa. •

302. Of the number of disputed boundaries of villages, *viz.*, 55, mentioned in paragraph 307 of the General Report for last year, nine cases have been settled, leaving a balance of 46 still in dispute; owing to these, the records and maps cannot be completed.

A survey, on the scale of 16 inches to a mile, has been made during the season of Shortt's Island, which had been left in abeyance for reasons given in paragraph 310 of last year's report.

303. The office of the party was inspected in July 1891 by the Deputy Surveyor-General, Revenue Branch. The preparation of the cadastral sheets and the state of the records was all that could be desired. A meeting was also held at the survey office with the Director of Land Records, Lower Provinces, and the Settlement Officer, Orissa, when the estimates and future programme of the party were discussed. A conference was also held at the Commissioner's house, when the system to be pursued in the revision survey of the irrigated lands, and other minor questions were decided.*

BURDWAN KHAS MAHALS, BENGAL.

DETACHMENT.

304. This detachment was to have been absorbed into No. 8 party (Orissa), but, owing to representations made by the Manager, Burdwan Raj Estate, it was decided to retain the services of Mr. Shaw and a small staff for a further period of one year.

Personnel.
Mr. T. Shaw, Assistant Surveyor, 1st grade, in charge.
9 field surveyors and others.

305. The programme for the field season's work consisted of—

(*a*) The relaying of the boundaries, as shown on the old *thakbust* maps of 1854, of 21 *mauzas* in district Bankoora, which were admitted by the Manager to have been permanently leased.

(*b*) The cadastral survey of all lands in district Burdwan that had been omitted from measurement during previous seasons.

306. The field office of the detachment was opened at Raneegunge on the 20th December 1890; and, until the arrival of instruments on the 5th January 1891, the necessary comparison of the old 4-inch revenue survey maps of 1855, with the *thakbust* maps of 1854-55 and the boundary surveys executed in 1889-90, was being made prior to starting the demarcation in district Bankoora.

307. The relaying of boundaries of the 21 *mauzas* was completed on the 20th January. The demarcation of each village was tested by independent surveys of the boundaries of each *mauza* on the 4-inch scale. The salient points on the boundaries of the *mauzas* so relaid were marked by 400 drain pipes of 3-inch diameter, obtained from Messrs. Burn & Co. of Raneegunge. The cost of these pipes as well as the cost of embedding them was borne by the *raj* management, and forms no part of the amount shown as survey expenditure, although the work was done by the detachment.

* Messrs. Ewing, Madras and Kraal, in charge of the three sections of this party during the season, are mentioned as deserving credit for the manner in which they supervised the work of their respective sections.
The Junior Assistants, Messrs. Berkeley, Barker and Gasper are said to have rendered efficient aid.
Mr. Pyster, Supervisor on the temporary establishment, is commended for the energy displayed by him and the satisfactory way in which he worked.
The following sub-surveyors, &c., are specially mentioned:—
Sheik Abdulla, Monohar Lall, Sheonarain, Jowalapershad, Gajadhar, Raghubir Saran, Futteh, Mohamed, Runglal, Mohamed Taki, Lalji Sahai, Jagobandhu, Kanungo, Nazir Hassan, Fariduddin Dianydhi Dass.

308. Much unsatisfactory delay was caused in starting the field-to-field survey of lands omitted during previous operations, owing to the ignorance of the *raj* officials about the situation and extent of the lands to be measured. They are very much scattered and situated in 99 villages, extending from Culna on the Hooghly river to Sainthia station on the East Indian Railway, a distance of nearly 70 miles. The average size of the blocks measured is 4·73 acres only, and that of the fields 0·34 of an acre. The cost of surveying such small and scattered areas has necessarily been high, being R1-4 an acre, including maps, records, tracings, etc. The lands were known to be situated in nearly 100 villages; but as they were pointed out for measurement in a most desultory manner by the *tahsildars*, it was not known what the area would ultimately prove to be. The lands, too, are situated in villages not in *khás* possession, and tenants were with difficulty induced to attend when the necessary entries were being made in the records. The cost of this work cannot, therefore, be compared with that of similar operations in other parts of the country.

309. The following statement shows the out-turn of cadastral survey during the season under report:—

District.	No. of villages.	No. of blocks.	No. of fields.	Area in acres.
Burdwan	89	535	7,091	2,310
Beerbhoom	10	50	934	259
Total . .	99	585	8,025	2,769

310. The measurement of the smaller blocks and isolated fields was tested by an inspector in the field, while through the larger blocks test lines were run over selected portions of the maps and recorded in a field book, the results being plotted and compared with the maps which had been kept in the office.

311. During recess the work performed by the detachment was somewhat different from that usually done by cadastral parties. In district Midnapore, the *mahal* comprises 66 villages, which constitute *pargana* Sujamutha. These villages, although all belonging to the *raj*, are made up of 13 different *tauzis* or properties; seven paying revenue to Government and six being revenue-free. The Manager pointed out, at a conference held at Burdwan on the 29th June, when the Director of Land Records and the Deputy Surveyor-General were present, that these had all been measured as one estate, and that the record of rights had been similarly treated. It was necessary, he said, to have these separate *tauzis* marked on the survey maps and the records corrected to agree with the maps. The Manager further brought to notice that the boundaries, as pointed out by the *raj* officials at the time of cadastral survey in 1888-89, did not, in all cases, correspond with the boundaries, as they existed at the time of *thakbust* survey in 1854; and that the *zamindári* papers were based on the limits of villages as they existed at this latter mentioned period. The old boundaries were consequently entered on the original plans and on the tracings supplied to the Settlement Officer and the Manager. The different *tauzis* were also shown on the tracings by means of distinguishing colours in accordance with the *thakbust* maps. This method of showing different *tauzis* on the tracings, as also revenue-free, *ghatwali*, and other lands marked on the *thakbust* maps, was extended to districts Burdwan and Bankoora; the old *thakbust* boundaries being likewise shown on the tracings. Although in district Burdwan the boundaries of *mauzas*, as now pointed out, differ in many places from the old boundaries, yet the number of *mauzas* has remained the same; but in district Bankoora very few indeed of the *mauzas* now recognised on the ground correspond with those shown on the old revenue survey and *thakbust* maps. The comparison of boundaries and colouring of *tauzis* in district Burdwan have all been completed; and it was anticipated that the same would have been done for all the *mauzas* of Bankoora; but the difficulties in this district were greater than was expected. The *mauzas* are so mixed up that portions of six, seven, and sometimes ten

original villages now go to form one village according to the statements made by the villagers to the sub-surveyors.

312. The following statement shows the number of village tracings to be compared and coloured and the number actually completed up to date of report :—

District.	Total villages.	Compared and coloured.	Remaining.
Burdwan	62	62	...
Sujamutha	68	66	2
Midnapore			
Bankobra	366	150	216
Hooghly	24	...	24
Nuddea	1	...	1
TOTAL	521	278	243

313. For district Midnapore, the *khasras*, *safawar*, and *milan khasras* of 62 villages have also been corrected to agree with the map, and corrected records of 56 villages were returned to the settlement officer. The rectification of boundaries in Sujamutha has involved correction of the following :—

(*a*) Original field plans.
(*b*) Two sets of tracings.
(*c*) Offsets in village traverse tables.
(*d*) English area statement.
(*e*) *Khasras*.
(*f*) *Safawar* and *milan khasras*.

314. The work remaining for this detachment during 1891-92, according to the wishes of the Manager, consists of—

(1) Cadastral survey of lands gazetted in November 1889, but not carried out through want of demarcation.
(2) Cadastral survey of lands gazetted on 11th November 1891.
(3) Cadastral survey of lands already gazetted, but found on the comparison of old and recent maps to have been omitted from measurement; either through ignorance on the part of the *raj* officials, or connivance on their part with opposing interests.
(4) Traverse survey of *tauzis* Nos. 1, 2, and 3, district Bankoora, area about 650 square miles.

Of these four items only the fourth has as yet been sanctioned by the Government of Bengal, but it is believed that the other three will also receive sanction. After this it is to be hoped that the detachment will be available for more remunerative work, as the scattered and desultory nature of its operations has made the work costly and unsatisfactory. The Manager has also sent up a proposal for a survey training school, and this will probably be opened during the coming field season.

315. On the 29th and 30th June the Deputy Surveyor-General, in charge Revenue Branch, visited Burdwan and held a conference with the Director of Land Records and the Manager of the Burdwan Estate, at which the results of the previous work and the necessity of retaining the detachment another year to make the boundary survey of *tauzis* Nos. 1, 2, and 3 of district Bankoora, were discussed. It was then decided that if the Manager could prove that he had been able to resume possession of any of the missing villages in consequence of the survey operations already completed, that the detachment should again be allowed to remain in Burdwan. With reference to this the Director of Land Records, in his report for 1890-91, has written thus :—

"The present Manager, Lala Bun Behary Kapur, reports that the work done is valuable to the *raj*; that he has been enabled to resume possession of some of the missing villages, and that though opposed to the undertaking of the survey at the beginning, now asks for the extension of it to *tauzis* Nos. 1, 2, and 3 of the Bankoora district."

316. Mr. Shaw has been two years in charge of this detachment, during which he has carried on the work required of him with diligence and skill. His work has been of a scattered and peculiar nature and the results cannot be gauged by the area turned out. That his work has been of use and the results satisfactory to the manager of the estate is proved by the fact that his services have been asked for, for two years more than was originally intended.

TRAVERSE SURVEYS.

MANDLA AND BETUL DISTRICTS, CENTRAL PROVINCES.

No. 9 PARTY.

317. This party of the strength shown in the margin having completed, during the previous season, the traverse survey of the Chanda and Bhandara districts of the Central Provinces, left its recess quarters Kamptee and assembled at Jubbulpore on 10th November 1890 to arrange for the survey of the district of Mandla. Field operations were commenced at the latter end of the same month, and continued until the 1st of May 1891. A detachment was started from Kamptee at the same time for the revisionary survey of the Betul district, and continued operations there until the end of June, when the work was completed. The Mandla party returned in May, and the Betul detachment in July, to recess quarters at Jubbulpore.

Personnel.

Mr. G. H. Cooke, Officiating Deputy Superintendent, 2nd grade, in charge.
„ C. F. Erskine, Assistant Superintendent, 2nd grade, from 15th December 1890 to 1st August 1891.
„ H. Dowman, Surveyor, 2nd grade.
„ A. George, Assistant Surveyor, 1st grade.
„ C. H. G. Johnson, Assistant Surveyor, 3rd grade.
„ G. Rae, Assistant Surveyor, 3rd grade (on probation).
35 sub-surveyors and others.

318. At the request of the Commissioner of Settlement and Agriculture, a block of 46 villages, covering an area of about 70 square miles, was taken up by traverse survey in Makrai Feudatory State within the borders of the Hoshangabad district by this party. A small detachment was told off for this at the latter end of the field season, and it completed the work just as the monsoon set in.

319. The traverse survey in the above districts has been of the same character as that undertaken in previous seasons, and the procedure in carrying on the work similar in every way, the object of the survey being to provide skeleton plots for the Settlement Department. Out of the total area of 5,200 square miles in the Mandla district an area of 3,069 square miles was completed during the season under report, leaving a balance of 2,131 square miles for season 1891-92.

320. In Betul, the traverses of upwards of 500 villages have been revised and extra sub-traverses run through the patches of cultivation in jungle tracts; 66 outlying *malguzari* villages scattered in Government forest reserves have also been surveyed, thereby completing the district. The plots and areas of all these have been furnished to the Settlement Department.

321. The out-turn of the season is shown in the following statement:—

District.	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Mandla	1,369	1,840	45,521	3,069
Betul	66	70	1,980	92
Makrai State	46	76	2,289	68
TOTAL .	1,481	1,986	49,790	3,229

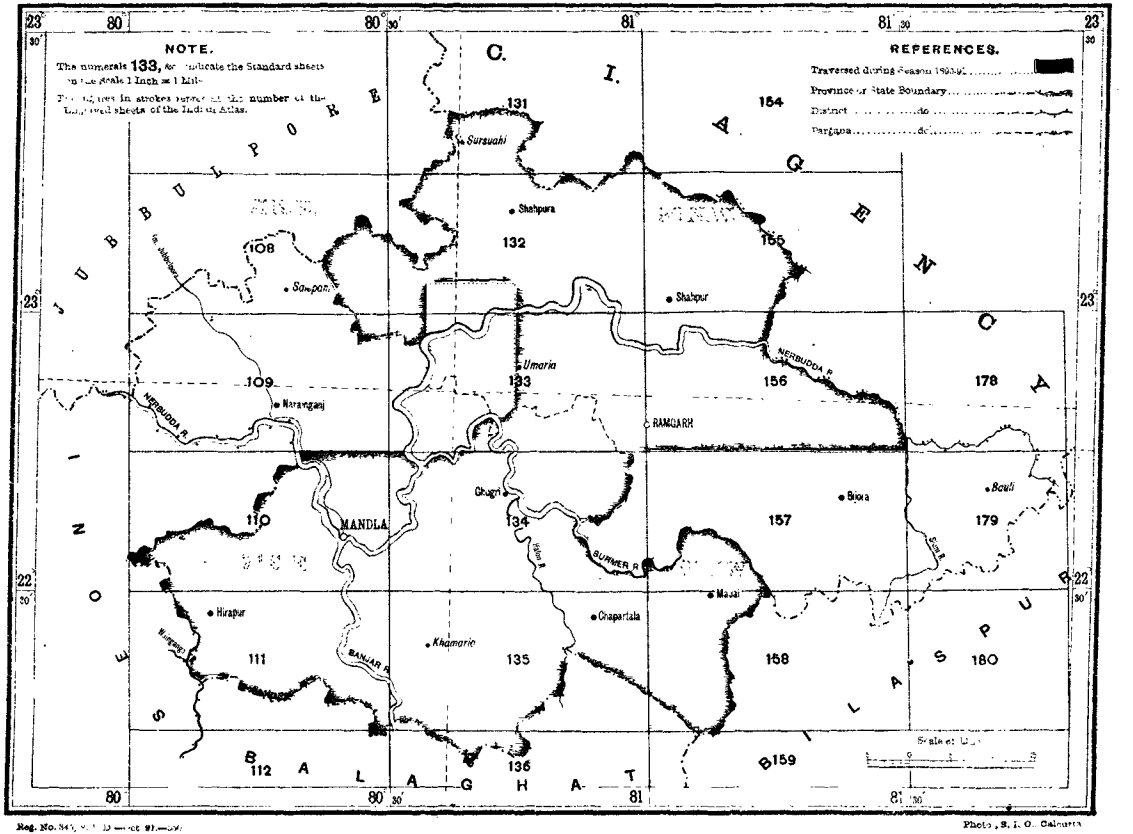
322. Traverse stations have been marked by dressed stones of the usual dimensions, embedded along the village boundaries between tri-junctions, as well as on the sub-traverse lines in the interior of villages; 38,935 of these marks have been laid down during the season at a cost of 3 annas 9 pies each, or R2-15-6 per square mile.

323. The demarcation of some of the villages in Mandla, at the time the survey operations commenced, was in a very backward state, and a smaller out-turn was effected than might have been done had the demarcation been complete. This, however, was impracticable, owing principally to the conversion of Government waste lands into *rayatwari* villages, which were being demarcated

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICT MANDLA.

No. 9 PARTY.



Reg. No. 34[illegible] — Oct. 91.—[illegible]

Photo., S. I. O., Calcutta

and allotted out to tenants at the time the survey passed over the ground. As there were no maps of the Mandla district showing village boundaries which could be utilised to frame an index to the traverse survey, it was found necessary to prepare, as the work advanced, skeleton plots on the 2-inch scale, showing the positions of all the survey stations. These skeleton plots will eventually be handed over to the Settlement Department as a record for their use. A trace from these plots has been made for the use of the *malguzars*, as a guide to the positions of the marks for the safe preservation of which they are held responsible.

324. The country traversed this season in Mandla to the south and south-east is level and well cultivated, and composed of rich black cotton soil, whilst the northern and eastern portion is wild and rugged, intersected by numerous streams running at a great depth below the surface of the ground and flowing between steep banks, which make them almost impassable and difficult for traverse work. The country also is very hilly, with a great variety of features composed principally of plateaux ranging from 100 to 2,000 feet in height. The climate from November to February is very malarious, and the members of the party suffered very severely from a bad type of fever during those months, caused by the heavy dews and cold nights, and excessive heat during the day, but the sickness decreased as the season advanced. Altogether 12 deaths occurred and many men were invalided.

325. Skeleton plots on the 16-inch scale have been prepared of the whole season's work, comprising 1,369 villages on 2,475 sheets: these with area statements and traverse data have been made over to the Settlement Department.

326. The party during the season of 1891-92 will be divided into three sections: the first working in Mandla, the second in Bálághát, and the third in Bhandára. The Mandla district in which 2,131 square miles remain will be completed next season, but in Bálághát, where 1,772 square miles of forest lands and *zamindari* villages, and in Bhandára where 1,127 square miles of *zamindari* villages have to be traversed, completion cannot be guaranteed as the aggregate area to be traversed amounts to over 5,000 square miles. Every endeavour, however, will be made to complete the three districts during the coming season.

327. The Deputy Surveyor-General inspected the office of the party on the 5th and 6th of September, and on the 8th idem he met Mr. Fuller, the Settlement Commissioner, with whom he conferred as to the general progress made by, and the future programme of the party, as well as on other matters. The books and records of the party were found in good order, and to Mr. Cooke much credit is due for the large areas he has turned out in a very difficult country.*

LOWER BURMA.

No. 12 Party.

328. The object of the work of this party was the same as that of last year, namely, the supplying of skeleton plots of traversed points to serve as a basis for the field-to-field survey, to be undertaken by the local survey agency under the Settlement Department.

Personnel.

Mr. E. J. Jackson, Officiating Deputy Superintendent, 2nd grade, in charge up to 21st July 1891.
Mr. F. Grant, Officiating Deputy Superintendent, 4th grade, in charge from 22nd July 1891.
Mr. W. S. Buttress, Surveyor, 2nd grade.
„ E. G. Little, Surveyor, 2nd grade.
„ R. B. Smart, Surveyor, 3rd grade, from 1st November 1890.
Mr. J. Newland, Surveyor, 4th grade, up to 31st October 1890.
Mr. P. J. Serrao, Assistant Surveyor, 2nd grade, up to 31st October 1890.
Mr. W. E. Johnson, Assistant Surveyor, 2nd grade, from 1st November 1890.
Mr. T. W. Babonau (Junior), Assistant Surveyor, 2nd grade.
Mr. F. S. Bell, Assistant Surveyor, 2nd grade.
45 sub-surveyors and others.

329. The tracts in which operations were carried on are situated in the districts of Prome, Hanthawaddy, Tharrawaddy, and Henzada, and are hilly and covered with dense jungle, and of such a nature that traverse lines could only be run with great labour and at great expense. To still further add to the difficulties, the portions to be surveyed were much scattered, rendering the superintendence of the field work laborious; thus there was one tract of 300 square miles in Henzada, another of 325 square miles in

* Mr. Cooke favourably mentions Mr. C. F. Erskine, who was attached to his party for a few months only, and reports that Mr. H. Dowman has shown his usual zeal and energy in turning out a large area, also that Messrs. A. George and C. H. G. Johnson have given satisfaction. Of the Native establishment the following have merited approval:—Lall Mohun Gangopadhya, Narsoo Dinkar, Tara Prosonno Roy, Behari Lall, Upendra Nath Mukerjee, Manohar Daji, Kesho Vaijnath, Gopal Setaram, Ganpat Rai, Murli Manohar and Karim Ulla Khan.

Tharrawaddy, and in Hanthawaddy and Prome, three separate areas of 74,15 and 651 square miles respectively, besides 182 square miles of revision work in these last two districts.

330. In order to deal effectively with these scattered areas the party was divided into three distinct camps, each camp being placed under an experienced surveyor with an assistant to help him; the European supervision was therefore costly for the area turned out, but this was unavoidable under the circumstances. The three camps took the field on the 23rd, 25th, and 27th November respectively, returning to the recess quarters in Rangoon on the 29th May, 19th and 21st June. The head-quarter camp took the field on the 8th December, returning to recess on the 14th June; it remained at Prome during the field season.

331. Of the area surveyed, only about one-fifth was under cultivation, the cultivated portions extending along the banks of the rivers up valleys, and on low lying lands. The boundaries of the *kwins* (villages) along which traverses had to be run, generally passed through jungle or along creeks, and the line clearing was this year again very heavy. The demarcation of these boundaries was very deficient in some parts of Prome, and as the *thugyis* in many places could not, or would not, point them out, much delay was incurred. In other places there was no demarcation at all, and the traverse surveyors ran their lines along the boundaries shown them by the villagers; these were accepted and subsequently marked out by the local authorities. The denseness of the jungle and the labour of traversing through it is proved by the fact that in such parts the average length of each traverse line was only 3 chains, whilst the average throughout the whole work, including the open portions, was only 8½ chains. This shows that the country was even worse for survey operations than that surveyed last year, but in consequence of the larger size of the *kwins*, the number of stations per square mile was only 20 as against 27 of the previous year. Out of the 26,937 new stations, 24,798 were marked with burnt clay cylinders. The following table gives the out-turn of traverse work for the season, in the different districts:—

Name of District.	Number of *kwins*.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.	Remarks.
Hanthawaddy . .	52	...	779	73·72	This area includes 84 square miles of forest land, of which the 16-inch plots are not required.
Tharrawaddy . .	116	23	2,365	114·44	
Prome . . .	361	65	14,655	665·73	
Henzada . . .	200	39	9,138	510·45	
Total .	729	127	26,937	1364·34	

332. The preservation of the traverse stations of the survey of 1882-83 does not appear to have been attended to in all places. Two circuits which had been originally surveyed as forest reserves were this year divided up into *kwins*; in one of them some of the old stations could be found. Several efforts were made to identify a few on which to close the new traverses, but without success, and it will now be necessary to re-traverse the whole of that forest reserve to allow of this being done. The searching for these old traverse stations caused a considerable loss of time. Another source of delay was, that in many cases the sub-surveyors had to be sent back to ground which they had already worked over, as it was found, after the traverses had been completed, that the *kwins*, as originally laid out, were too large, and these had to be sub-divided; in some cases the original *kwins* were cut up into four or five smaller ones.

333. During the field season, the 16-inch plots of *kwins* were supplied to the Superintendent of the field survey agency as soon as they could be got ready. One hundred and three *kwins* of the work of last year, the survey of which had had to be revised, and 495 *kwins* of the current season's work were thus sent to the field survey camp. The plots of the remaining *kwins* which do not require revision will be submitted before the party takes the field. Besides the 16-inch skeleton sheets, others on the 4-inch scale were plotted, and tracings of these in duplicate were made on the notices supplied to *kyedangyis*; the *kyedangyi* kept one copy and sent the other to the Deputy Commissioner's office after having

BURMA SURVEY.

INDEX TO THE TRAVERSE SURVEY IN LOWER BURMA.

No. 12 PARTY.

signed it. Plots on the 2-inch scale were also made of all the *kwins* on the regular standard-sized sections, and these were supplied to the Settlement Department for the purpose of inserting thereon the topographical details obtained from the cadastral survey.

334. The health of the party generally was good; there were altogether 10 deaths, four of which occurred at one place and at one time; these last were supposed to be from cholera, but there is reason to believe that they were caused by some poisonous food.

335. The head-quarter camp at Prome was inspected by the Deputy Surveyor-General on the 8th of May, and a conference was held at Rangoon with the Director of Land Records on the 11th idem, when the question of the more rapid supply of plots to the field survey party was discussed. There is no doubt this party had very great difficulties to contend with, inasmuch as the country surveyed was of such a nature that during the former operations it was declared to be impracticable to make a regular connected survey of it. This has, however, now been done, at considerable cost no doubt, but that could not be avoided. Mr. Jackson and his assistants deserve credit for having turned out an area of 1,364 square miles in such a country.

336. It has been decided that whatever traversing remains in these districts shall be done by the supplementary survey under Mr. Clancey, and an assistant surveyor from this department has been temporarily deputed by the Local Government, with a view to assist in training and supervising the natives who are to run the traverse lines. This party is therefore free to take up cadastral work in Upper Burma according to the fixed programme of survey operations for the next year which was agreed upon at a conference held at Rangoon on the 25th of April, and at which the Chief Commissioner, the Financial Commissioner, the Director of Land Records, and the Deputy Surveyor-General, Revenue Branch, were present. Instructions have been issued for the party to commence work in the district of Minbu.*

GEODETIC.

LATITUDE OPERATIONS.

NOS. 22 & 23 PARTIES.

337. Owing to Captain Burrard having taken furlough on medical certificate, it was found necessary to relinquish the electro-telegraphic longitude operations, for which two officers are required, and to proceed with the latitude operations.

Personnel.

Lieutenant G. P. Lenox-Conyngham, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Dhondo Balwant Joshi, Sub-Surveyor.
Govind Balwant Joshi, Lall Singh, and Hanuman Prasad, Recorders.

338. Lieutenant Lenox-Conyngham, who had been the second observer on the longitude operations of the previous season, was therefore placed in charge of the latitude work. The instrument used was the new zenith telescope by Troughton and Simms (designed for the application of the so-called Talcott's method) which had been received in September 1890.

339. The latitudes of seven stations between the parallels of 13° and 15° 56′ north latitude were determined, situated on the Madras meridional series of the Great Trigonometrical Survey, which runs approximately along the meridian of 80°. The results obtained show that the instrument, notwithstanding its comparatively small size and weight, is capable of giving results very nearly as good as those obtained by the zenith sector. The probable errors of the

* Mr. Jackson speaks very highly of Messrs. Buttress, Little, and Smart, who were each in charge of one of the camps. Of Messrs. Babonau, Johnson, and Bell, he says that they are hardworking, deserving, and well-behaved assistants. He especially mentions Babu Rajendra Chatterjee, Rheedoy Chunder Dass, Gulam Hyder, Moti Lall, Vishnu Sitaram, Tej Ram, Abdul Wahid (1), Abdul Wahid (2), Makhil Hosein, and Abdul Karim.

latitudes of the several stations varied between $\pm 0.''077$ and $\pm 0.''041$, the average being $\pm 0.''056$; as compared with $\pm 0.''048$ and $\pm 0.''050$ with the zenith sector for the two last seasons in which it was used.

340. It is noteworthy too, that the probable error of the deduced result steadily decreases from that at the first to that at the fourth station, and then it becomes very steady, with an average for the last four stations of $\pm 0.''047$. This points rather to the larger probable error of the first three being due to inexperience in the use of the instrument. By a scrutiny of the deduced latitudes with their probable errors it will be seen also, that an increase of the number of stars observed is more valuable for obtaining precision in the result, than an increase in the number of observations.

341. The programme of observations at all but one station consisted of taking two sets of 20 pairs of stars each, each set being observed four times. At one station three sets of 20 pairs were observed, each twice; this procedure would have been more frequently adopted had it been possible to obtain more pairs of stars. It is hoped that in more northern latitudes this difficulty may not be so great.

342. The system of determining latitude by what is known as Talcott's method, though well known in America, had not been tried in India before this season, and it is a matter for congratulation, that the excellent results obtained thereby, fully justify its adoption for the future in all latitude operations in this country. The zenith telescope is not $\frac{1}{10}$th the weight of the old zenith sector designed by Colonel Strange; it is far less complicated in its use and adjustments, and can be set up ready for use in a mere fraction of the time required for the latter. There is one drawback, and one only, to its use and that is, the paucity of stars in the catalogues of the southern heavens, suitable for combining into pairs at approximately equal zenith distances. This is a matter that may occasionally somewhat tax an observer's patience, but it is otherwise of little consequence.

343. The zenith telescope does not seem to have any of the idiosyncrasies which were noticed in the zenith sector, nor were they much to be apprehended in so small an instrument. Lieutenant Lenox-Conyngham reports favourably of the make and general convenience of the instrument, but states that the levels which were supplied with it were by no means as good as they should have been. The larger of the two, on which the accuracy of the method in great measure depends, he took off and replaced by one made by Holmes, which was in store in the Dehra office; of this level he speaks very highly. As there was no spare level of suitable size obtainable, the transit axis level was allowed to remain, but will be replaced by a better one before the instrument is again used.

344. The following table shows the results of the season's observations and gives a comparison between the astronomical and geodetic latitudes:—

Station.	No. of pairs observed.	No of observations.	Astronomical latitude $=\lambda_o$ and probable error.	Geodetic latitude $=\lambda_c$	$\lambda_o - \lambda_c =$ apparent deviation of plumb-line.
Saint Thomas' Mount	40	122	13° 0′ 20″·66±·077	13° 0′ 14″·79	+5″·87
Madras Observatory	40	136	13° 4′ 9″·88±·067	13 4 2 ·06	+7 ·82
Gudali	48	172	14° 1′ 10″·65±·056	14 1 9 ·45	+1 ·20
Kistama	45	168	14° 27′ 12″·30±·050	14 27 14 ·56	−2 ·26
Darutippa	61	121	15° 0′ 33″·52±·041	15 0 36 ·47	−2 ·95
Ongole	47	171	15° 29′ 52″·90±·051	15 29 56 ·85	−3 ·95
Dánapa	45	172	15° 55′ 59″·70±·050	15 56 0 ·14	−0 ·44

345. The very large number of stars which had to be observed in consequence of employing Talcott's method made the computations somewhat heavier than usual, but they have been successfully completed. Some details of the season's work will be found in Lieutenant Lenox-Conyngham's narrative report in the appendix.*

* Lieutenant Lenox-Conyngham mentions favourably Babu Hanuman Prasad, a new hand, whom he considers a promising recorder, and speaks highly of the services of Kali Deen, tindal.

TIDAL AND LEVELLING OPERATIONS.

No. 25 Party.

346. The charge of these operations since the commencement of last field season has been in the hands of Lieutenant-Colonel J. Hill, R.E., who returned to India from furlough and relieved Mr. Wood, who had been acting for him for nearly eleven months, and who was then transferred to the charge of No. 7 Party in Rangoon.

Personnel.

Lieutenant-Colonel J. Hill, R.E., Deputy Superintendent, 2nd grade, in charge from 18th November 1890.
Mr. C. Wood, Assistant Superintendent, 1st grade, in charge up to 17th November 1890.
Mr. G. Belcham, Surveyor, 2nd grade.
„ E. J. Connor, „ 3rd „
„ J. Bond, „ 3rd „

Sub-surveyors, etc.

Narsing Das and Dhondu Vinayek, 2 native mechanics, and 18 recorders and computers.

Tidal Operations.

347. The recording of the tidal curves by means of self-registering tide gauges, their reduction, and the publication of the predicted times and heights of high and low water have been continued, and tidal observations have been carried on during the year at seventeen stations, *viz.*, *Aden*, *Kurrachee*, Bhávnagar, *Bombay* (*Apollo Bandar*), Bombay (Prince's Dock), Cochin, Minicoy, Tuticorin, Trincomalee, Madras, Cocanada, *Kidderpore*, Chittagong, Akyab, *Rangoon*, Mergui, and *Port Blair*. The eleven tidal stations whose names are not italicised are minor stations, where observations, as a rule, are taken for five years only. The others are *permanent* stations, where the minimum duration of observations is for nineteen years, and where observations should be continued until the whole scheme of tidal operations has been completed.

348. Since the date of the last report, work has ceased at three stations, *viz.*, Madras, Cocanada, and Chittagong. At Madras the observatory worked for ten days only, the Madras Government having decided, as mentioned in the above report, to discontinue the tidal registrations. At the minor stations of Cocanada and Chittagong the observatories were closed on the 18th April and 22nd July respectively after the completion of five years' observations. Two new tidal observatories have been established, one at Trincomalee and the other at the island of Minicoy, where observations were commenced on the 10th of November 1890, and on the 12th January 1891, respectively.

349. Thus, since the resumption of systematic tidal operations in 1877, observations have been taken at 31 tidal observatories, of which 17 (including Madras) have been closed on the completion of their registrations, and 14 are now in operation.

350. The commencement of tidal observations at the four following new minor stations have been sanctioned:—Diamond Island, Sálbet, Muscat, and Bushire. At Diamond Island the work connected with the erection of the observatory is in progress. At Sálbet there has been an unexpected delay in the local arrangements for commencing work, but it is hoped that the Bhávnagar authorities will have the observatory built at an early date. It is expected that the establishment of the tidal observatories at Muscat and Bushire will be undertaken about next February.

351. All the tidal observatories, excepting Bhávnagar, have been inspected, and a detailed account of the working of each will be found in the appendix. If the discontinuance of tidal registrations at Madras and the unsatisfactory nature of the recent observations at Aden be excepted, the results obtained at the various tidal stations may be pronounced very satisfactory. This is to a great extent due to the assistance received from the local officials, whose kind co-operation has been acknowledged by Colonel Hill.

352. The reduction of the tidal observations has been carried on steadily during the year. Observations for one year at twelve stations and for two years at three stations have been reduced, the total calculations being thus equivalent to the reduction of 18 years' observations at one station. The tabulated values of the tidal constants so obtained will be found in the appendix. In addition to them, constants to be employed in setting the tide predictor were calculated for

the year 1892 and sent to Mr. Roberts of the Nautical Almanac office ready for use; he was also furnished with tabulated comparisons for the year 1890 between the predicted times and heights of high and low water published in the Tide Tables for that year and their values obtained by actual measurement, thus giving him in a convenient form information to enable him to improve subsequent predictions where necessary.

353. The Tide Tables for 1892 will contain predictions for 31 tidal stations, no new station having been added since the last issue.

354. In addition to the usual tables a second instalment of the completed tidal work is given this year. The first instalment was contained in Tables Nos. 1 and 2, page xlii of the appendix to the report for 1886-87. The tables now given, which are similarly numbered, give the values of the tidal constants at eight stations closed since that report was submitted. Table No. 1 gives the values in feet and degrees of the mean amplitudes and epochs of the tidal components, and Table No. 2 their values in terms of the Main Lunar Tide M2 for comparison with the equilibrium theoretical values.

355. The results of the predictions for 1890 may be summarised as follows:—

Percentage of Time predictions within 15 minutes of actuals.

	High water, per cent.	Low water, per cent.
13 Open coast stations	69	70
4 Riverain stations	60	59

Percentage of Height predictions within 8 inches of actuals.

	High water, per cent.	Low water, per cent.
13 Open coast stations	95	93
4 Riverain stations	65	64

Percentage of Height predictions agreeing with actuals within $\frac{1}{16}$th of mean range at springs.

	High water, per cent.	Low water, per cent.
13 Open coast stations	91	91
4 Riverain stations	90	86

These figures show a slight falling off, chiefly in the time predictions, from the exceptionally good results obtained in 1889; they are nevertheless above the average, and may be considered on the whole to be very satisfactory.

Spirit-Levelling Operations.

356. The levelling operations of the last field season comprised the following lines of double levelling:—

Section from Rajkot to Bhávnagar.

Section from Sanosra (Bhávnagar-Gondal-Junagad-Porbandar Railway) to Chachúda Temple, opposite Sálbet, with branch line to Port Albert Victor.

Section from Naydongri (Great Indian Peninsula Railway) to Málkhed (Nagpur line).

The total out-turn amounted to 425 miles of double levelling, in the course of which the heights of 435 permanent bench-marks and three stations of the Great Trigonometrical Survey have been determined. This is a good out-turn, and it would have been larger had all the sections been continuous; but three weeks were lost in changing ground. Every assistance was given to the levelling detachment by the Railway and local officials, for which Colonel Hill has expressed his obligations.

357. It is intended to extend the levelling operations continuously during next season along the Nagpur line in the direction of Burdwan.

358. In addition to the regular departmental work of the tidal and levelling party, the Calcutta Municipal Corporation were furnished with the actual time and height of every high and low water at Kidderpore for the 15 months extending from 1st August 1889 to 30th November 1890, for use in connection with

the important works contemplated for the improvement and extension of the drainage of Calcutta. Reports were furnished, on the operations in the Bombay Presidency and in Burma, to the Local Governments.

359. The recess office of this party at Poona was inspected by the Deputy Surveyor General, Trigonometrical branch, in August 1891, and was found to be working satisfactorily in all respects. The tidal work entails a vast quantity of arithmetic, the dealing with which requires much care and method. The system followed by Colonel Hill seems to leave nothing to be desired on this score. Arrangements were entered into to enable the office of this party and that of No. 10, to be located under the same roof in future, by which a considerable saving in house-rent will be effected.*

GEOGRAPHICAL SURVEYS.

OPERATIONS IN UPPER BURMA.

NO. 11 PARTY.

360. On Captain Jackson's departure on furlough in October 1890 this party was placed in charge of Mr. Ogle, who superintended the field operations and remained in charge of the party until the 1st of July 1891, on which date Captain Renny-Tailyour relieved him.

Personnel.

Captain T. F. B. Renny-Tailyour. R.E., Officiating Deputy Superintendent, 4th grade, in charge from 1st July 1891.
Mr. M. J. Ogle, Officiating Deputy Superintendent, 4th grade, in charge up to 30th of June 1891.
„ A. J. Wilson, Surveyor, 1st grade.
„ F. Kitchen, „ 3rd „
„ P. J. W. Doran, „ 4th „

Sub-surveyors.

Ikbaluddin, J. Sebastian, Kudrat Ulla, Ramsabad, Mowni Ram, Sita Ram, and Nuruddin

361. The operations were of a similar nature to those carried on during the previous year, *viz.*, geographical surveys in Upper Burma, south of the parallel of 22° N. latitude, on the scale of four miles to one inch. The work lay chiefly in the districts of Meiktila, Myingyan, Yamethin, and Magwé, and the survey of these districts was completed. In addition, portions of Pyinmana and Thayetmyo were surveyed.

362. The party left recess quarters at Bangalore on the 23rd of October, reaching Mandalay on the 5th of November, and field head-quarters were established at Magwé about the end of the month. The distribution of work for the field season was as follows:—

Mr. Wilson, with one sub-surveyor, to carry on the triangulation northwards from the Great Trigonometrical bases, Minbataung-Kabantaung and Kabantaung-Beyountaung, and to connect on with his last season's work. This was accomplished, and later in the season when the weather became hazy, he executed 536 square miles of topography.

Mr. Doran, with one sub-surveyor, to take up both the triangulation and detail survey in sheet No. 2 S. E. in the Magwé and Yamethin districts. This portion of the work was successfully completed.

Mr. Kitchen's original instructions were, with sub-surveyor Ikbaluddin, to take up work in sheet No. 5 N. W. in the Shan hills, but on its being notified that a column was to operate in the Baungshé country he, with the sub-surveyor, was detailed to accompany it. He accordingly proceeded to Pakokku by steamer, and marched thence to Gangaw, where he heard that the expedition had been abandoned. He succeeded, however, in making a rough reconnaissance of the country and in effecting a junction with the triangulation carried out by Captain Renny-Tailyour, whilst with the Burma column of the Chin-Lushai expedition of 1889-90 on the north, and also with Mr. Kennedy's work of the same year on the south. The area reconnoitred amounts to about 2,200 square miles, though, from the fact that the Baungshé country was not entered, the map is necessarily defective in the matter of the correct positions and names of villages.

* Colonel Hill reports most favourably of Messrs. Belcham and Connor in the Tidal Division, and of Mr. Bond and sub-surveyor Narsing Das in the Levelling Division. Mr. E. Bond and Mr. G. H. Belcham, temporarily attached to the party, are also favourably noticed. Sub-surveyor Dhondu Vinayek is specially mentioned; and the native mechanics and other sub-surveyors and computers have worked well and given satisfaction.

Mr. Kitchen and Ikbaluddin were subsequently employed in the Thayetmyo district, west of the Irrawaddy.

363. The field season closed on the 27th of May, when the party returned to Rangoon, embarking for Madras on the 31st and arriving at recess quarters in Bangalore on the 6th of June.

364. The total out-turn of work amounts to—

Triangulation	. . .	12,470 square miles.
Topography	. . .	11,964 „

Of the area mapped about 6,090 square miles are in the districts of Meiktila, Magwé, Myingyan, and Yamethin, which were completed, and about 3,800 square miles in portions of the Pyinmana and Thayetmyo districts and in the Shan States bordering on Meiktila. The remaining area was in the Baungshé country.

365. The programme for the next field season's work consists in the completion of sheets Nos. 5 N. W., 5 S. W., and 6 N. W., and as much of No. 5 N. E. as can be taken up. Triangulation will be carried on in the whole of the above tracts.

366. The Surveyor-General inspected the recess office of the party at Bangalore in September. It is located in the same building as the office of No. 21 party, with the work of which it is closely connected. The establishment was found to be in an efficient state, and the progress of the work in every way satisfactory.*

No. 21 Party.

367. The party under the charge of Major Hobday left recess quarters at Bangalore on the 23rd of October 1890 and proceeded to Mandalay. Major Hobday's services being required for the special expedition to explore the Upper Irrawaddy valley, Captain Longe assumed charge of the party on the 1st of December, and has retained it throughout the year. Captain Renny-Tailyour was also detached from the party at about the same date, for special duty with the expedition under Lieutenant Daly, which was to proceed along the eastern frontier of the Northern Shan States.

Personnel.

Major J. R. Hobday, S.C., Officiating Deputy Superintendent, 3rd grade, in charge up to the 30th November 1890.
Captain F. B. Longe, R.E., Officiating Deputy Superintendent, 3rd grade, in charge from the 1st December 1890.
Lieutenant P. J. Gordon, S.C., Assistant Superintendent, 2nd grade, from 1st December 1890.
Mr. H. T. Kitchen, Surveyor, 4th grade.
„ W. C. G. Barckley, Assistant Surveyor, 1st grade.
„ C. George, Assistant Surveyor, 1st grade.

Sub-surveyors.

Sher Shah, Alladad Khan, Mahomed Latif, Mahomed Alum, Mahomed Wazir, Mahomed Nawaz Khan.

368. The operations were similar in character to those carried on during the past five seasons, *viz.*, geographical surveys, on the scale of 1 inch = 4 miles, north of the parallel of 22° N. latitude.

369. The following programme of work for the field season had been arranged:—

Captain Longe and Lieutenant Gordon to extend the triangulation northwards from Bhamo and to join any expeditions that might proceed from Bhamo in the same direction.

Mr. Kitchen, with one sub-surveyor, to complete the unsurveyed portions of the Ruby mines and Mandalay districts, and to fill in several blanks in sheets No. 4 S.W. and No. 4 N.W.

Mr. Barckley and two sub-surveyors to complete such portions of the Upper and Lower Chindwin and Yeu districts as fall in sheets No. 1 N.E. and No. 1 S.E.

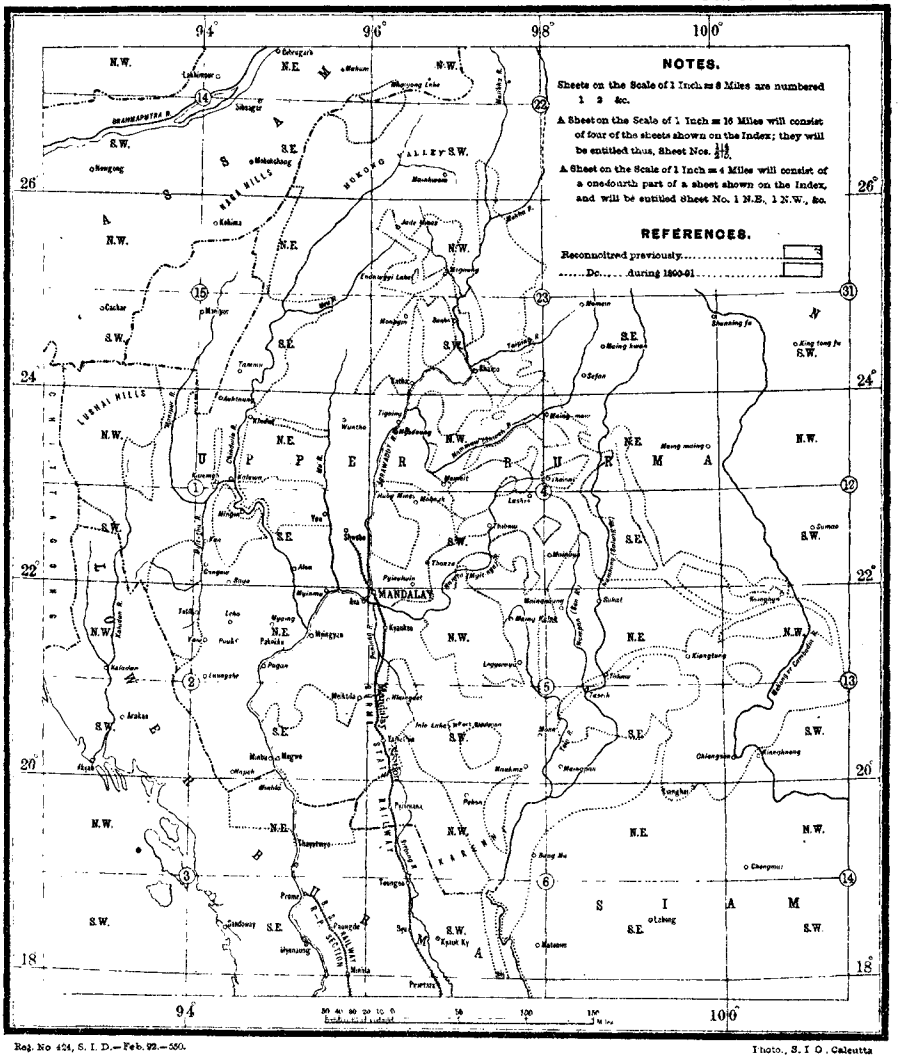
Mr. George and two sub-surveyors to complete such portions of the Katha and Shwebo districts, and of the Wuntho State, as fall in sheets No. 1 N.E. and No. 4 N.W. between the Mu and Irrawaddy rivers.

* Mr. Ogle reports favourably on the services of the European assistants. All the sub-surveyors also are mentioned as having worked well throughout the field season.

NORTH EASTERN & SOUTH EASTERN FRONTIER SURVEY.

INDEX TO THE GEOGRAPHICAL SURVEY IN UPPER BURMA.

Nos. 11 & 21 PARTIES.



Reg. No 424, S. I. D.—Feb. 92.—550.

Photo., S. I. O., Calcutta

By the 25th of November the above detachments had all left Mandalay to take up the work allotted to them, and on the 5th of the same month Captain Longe, with Lieutenant Gordon, transferred head-quarters to Bhamo, arriving there on the 8th.

370. During December, Captain Longe and Lieutenant Gordon extended the triangulation from Bhamo through Senbo to Mogaung, reaching the latter place early in January. From Mogaung, Captain Longe accompanied a small reconnaissance under Captain O'Donnell, which proceeded northwards to Thama. He was enabled to make a few additions and corrections to the survey made of this country previously by Mr. Ogle, but could visit no hills from which triangulation could be carried on, except one near Thama itself. The column remained in the vicinity of Thama until the 2nd of March, when it returned to Mogaung; meanwhile Lieutenant Gordon had proceeded up the Endaw Chaung to Endawgyi, sketching the river and the country in the immediate neighbourhood on both banks *en route*, after which he rejoined Captain Longe, in time for both officers to accompany a force under Captain O'Donnell which was to proceed to Taungton Lon hill, and near there, at a place called Payani, to meet troops sent from the south under Colonel MacGregor.

371. This expedition started from Mogaung on the 9th of March and, proceeding *vid* the Nam Yen valley and across the hills, reached Endawgyi on the 14th. During a halt here of three days, observations for latitude were taken each evening, a base line was measured, and some hills were fixed on ahead, in the direction to be followed by the column. Leaving Endawgyi on the 17th, the village of Mansain, on the Namsang river, was reached on the 19th and Payani on the 25th, where a small body of Colonel MacGregor's troops was met, and on the 29th Captain Longe rode to Na-aw to meet Brigadier-General Wolseley. Further details of the operations with this expedition will be found in the narrative report by Captain Longe in the appendix.

372. It was arranged at Na-aw that Lieutenant Gordon should accompany the column under Brigadier-General Wolseley to Kamaing and the Jade Mines, whilst Captain Longe returned to Bhamo. The expedition to the Jade Mines left Payani on the 1st of April, reaching Endawgyi on the 6th, where a junction was effected with the remainder of Colonel MacGregor's column. Arrangements were at once made to advance on the Jade Mines in two columns, one to proceed *vid* Sakaw and the other by the direct road from Endawgyi. Lieutenant Gordon accompanied the former column, and Colonel MacGregor kindly promised to give him a sketch of the route followed by the latter. The Jade Mines were reached on the 17th of April, and a durbar was held the same day, and next morning the column retraced its steps to Kamaing and Lieutenant Gordon reached Mogaung on the 22nd. Extracts from Lieutenant Gordon's report will be found in the appendix.

373. Sub-surveyor Sher Shah had been detached from the party early in the field season to accompany Lieutenant Burton's expedition into the Kachin hills to the north-east and east of Bhamo. He returned with the creditable outturn of 1,300 square miles, mapped on the $\frac{1}{4}$-inch scale, of previously unexplored country.

The head-quarters of the party were moved to Mandalay on the 14th of April, the several detachments arrived there by the 24th of May, and recess quarters at Bangalore were reached on the 6th of June.

374. The programme, as laid down, was completed during the field season, though the work was considerably retarded, in the case of Mr. George's detachment by the Wuntho rebellion, and by sickness in that of one or two others.

375. The total out-turn of work for the field season amounts to 11,330 square miles of topography on the $\frac{1}{4}$-inch scale, made up as follows:—

	Square miles.
Ruby Mines, and Mandalay districts	1,150
Yeu, Upper and Lower Chindwin and Pakokkú districts	3,430
Katha and Shwebo districts, Wuntho State	2,965
Bhamo district	1,300
Yatsauk and Thibaw States	985
Mogaung and Jade Mines	1,500
TOTAL	11,330

376. During the recess, new editions of the following sheets were compiled and drawn, *viz.*:—No. 1 N.E. and S.E., No. 23 N.W. and S.W., No. 4 N.E., N.W., S.E. and S.W., and in addition three sheets, embracing the work of Captain Renny-Tailyour and Mr. Kennedy, were also completed.

377. The field office of the party was inspected at Mandalay in May by the Deputy Surveyor-General in charge Revenue Branch, and the recess office at Bangalore in September by the Surveyor General. The recess work was found to be well advanced, the professional records in good order, and the mapping sufficiently good for the purposes of a preliminary survey. A very large amount of drawing devolved on the party during the recess, for, in addition to the mapping of the areas surveyed by the party, special maps had to be prepared of the surveys done under Captain Renny-Tailyour and Mr. Kennedy on the Siam frontier, and which were urgently required by the Foreign Department. Owing to the constant and urgent demands in Upper Burma for the latest geographical information, new editions of the standard sheets have to be brought out yearly, and to enable the work to be reproduced as quickly as possible, the drawing and printing is of necessity of a more rough character than in the regular publications of this department. At the same time they are quite clear and legible, and the advantage of obtaining quickly geographical maps of first surveys justifies a want of refinement in their drawing. The whole of the mapping in hand was completed by the end of the recess, and comprises new editions of eight standard sheets and the special map in three sheets previously referred to. Captain Longe and the members of the party are entitled to credit for the energetic manner in which they have accomplished the heavy task they had.*

OPERATIONS WITH MILITARY EXPEDITIONS ON THE NORTH-WEST FRONTIER.

378. The columns which operated on the Miranzai border, and on the Hazara frontier during the cold season of 1890-91, were each accompanied by small survey detachments. The survey officer with the first Miranzai expedition, under Brigadier-General Sir W. Lockhart, K.C.B., which commenced operations early in January 1891, was Captain Wahab, R.E. In spite of considerable difficulties in the way of exceptionally inclement weather, a considerable area was reconnoitred and mapped on the 1 inch scale, most of which was hitherto unsurveyed, or had been only mapped in parts on the $\frac{1}{4}$-inch scale.

379. On the breaking up of the Miranzai Field Force, Captain Wahab was detailed to accompany the force under Major-General Elles, C.B., which was to operate on the Hazara frontier. He joined at Darband on the 6th of March 1891, and carried on survey operations until the force was broken up on the 14th June, during which time the whole area covered by the military operations and a good deal beyond it, was surveyed on the scale of 2 inches to a mile: in addition, a large tract was reconnoitred on the $\frac{1}{8}$-inch scale, taking in the Indus valley up to near Kabalgram, and parts of the Chamla and Itai valleys, which join the Indus on the west.

380. Meanwhile events on the Samana range having necessitated the despatch of another force to the Miranzai border, Captain Mackenzie, R.E., was detailed to accompany the second expedition thereto, as Captain Wahab's services could not be spared from the Hazara Field Force. Captain Mackenzie with one sub-surveyor joined the force at Hangu on the 28th of April 1891, and was engaged on survey operations therewith until the 11th of June, when the force was broken up. The operations carried on by the parties attached to the different columns will now be described.

* Of the Assistants Captain Longe reports as follows:—

"Lieutenant Gordon, who was quite new to the work, accompanied me for the greater part of the season and reconnoitred about 850 square miles of new country. He proved himself to be very zealous, and has shown considerable aptitude for the work. He has received further instruction in triangulation and plane-tabling during the recess, and should now be quite capable of carrying on a survey independently."

Messrs. Kitchen and George are also favourably reported on. The last named is mentioned as follows by Brigadier-General Wolseley, C.B., Commanding the Wuntho expedition, in his dispatch dated 6th June 1891: "I would here also mention the good services rendered by Mr. George, Survey of India, who volunteered to remain in Kawlin during the trying times when it was in a state of siege, and who actively employed himself in the defence of the place.

Sub-surveyors Sher Shah and Mahomed Latif are also favourably reported on.

I.—The Operations with the Miranzai Field Force.

381. The survey detachment arrived at Kohat on the 12th January 1891, where it was detained by wet weather until the 19th. Hangu was reached on the 20th, and whilst the force remained there, every opportunity was taken, by ascending the Samana range at different points each day, of sketching all that could be seen of the Khanki valley and hills beyond. The party then moved to Darband with the 3rd column, crossing the Samana range on the 28th and reaching Gwada next day, where survey work was continued, and the Khanki valley from Inzaur downwards mapped as far as possible On the 3rd of February, Captain Wahab accompanied a reconnaissance to Daradar, and on the 4th marched to Kasha and thence to Khanrai, and thus completely sketched all the country south of the Shekhan range.

Personnel.

Captain R. A. Wahab, R.E., Deputy Superintendent. 3rd grade, in charge.
Duffadar Puran Singh, soldier surveyor.

382. From the 5th to the 8th February, the party worked with the second column, visiting the Shekhan valley and surveying it up to the Kharai Kotal which leads into the Mamozai valley. From the 9th to the 12th the Zera valley and the Sturi Khel country, as far as it could be seen from the hills within reach of camp, was reconnoitred and mapped On the 14th Captain Wahab returned to Kohat to complete the mapping and prepare tracings. The soldier surveyor was detailed to survey the part of the Samana range west of Sangar, which had not been previously visited, and this completed the reconnaissance of the whole country visited by the expeditionary force.

383. In all 95 square miles of country have been mapped on the scale of 1 inch to a mile, the greater portion of which had been hitherto unsurveyed or only partly mapped on the ¼-inch scale. The heights of all camps and important villages, passes, &c., have been fixed by clinometric observation to trigonometrically fixed points.

384. No triangulation could be done, though the detail survey would have been materially assisted, had some additional points been fixed. Constant bad weather during the few days spent at Hangu and Darband, with deep snow on the only points suitable for stations, and the want of the time necessary to clear them, effectually prevented the carrying on of any triangulation. After the advance beyond the frontier, Captain Wahab was fully occupied in the detail survey.

II.—The Second Miranzai Expedition.

385. Owing to Captain Wahab's services being still required on the Black Mountain expedition, Captain Mackenzie, R.E., was detailed to accompany the force operating on the Miranzai border for the second time.

Personnel.

Captain R. J. H. L. Mackenzie, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Hussein Baksh, sub-surveyor.

386. The party joined the force at Hangu on the 28th April, and on the 30th reached the Samana range, where work was commenced. Captain Mackenzie detailed the sub-surveyor to carry on a regular survey on the scale of 1 inch to a mile of the country in the immediate vicinity, whilst he himself paid special attention to the country ahead. On the 2nd May the party reached Gulistan, the most westerly station on the Samana occupied by the troops, and a sketch map of the Upper Khanki valley was got ready by the time the General Officer Commanding ordered an advance in that direction During this advance the 1 inch survey was carried up the valley as far as Khanki Bazar, and on the day the force reached this place a reconnaissance, which Captain Mackenzie accompanied, pushed on as far as the Marghan Kotal, and he was able to extend the survey up to that point on the ½-inch scale. From this kotal, bearings were taken down the Kurmana Dara, and to various villages mostly situated on the spurs running down to the stream.

387. After the return of the troops from the Khanki valley, the survey of the Samana range was completed, and a large scale plan of the Mastan plateau was made. Observations were also taken to fix points trigonometrically on the ranges to the north. This completed the survey work, and the party left Hangu on the 11th of June. In all an area of some 160 square miles of country was surveyed on the 1-inch scale (part of which was revision), 23 square miles were reconnoitred on the same scale, and 20 square miles on the ½-inch scale.

The services of the Survey Officers, with the Miranzai Field Force, have been acknowledged in the following terms by the Brigadier-General Commanding in his despatch dated 8th June 1891 :—

"Captain R. J. H. L. Mackenzie, R.E., has satisfactorily conducted the survey work of the expedition. He has been successful in extending the survey of the Orakzai country to the Tsappar range, south of Tirah, and to the Marghan pass and Kurmana valleys, thus completing the excellent work of Captain Wahab, R.E., whose name I brought to notice at the end of the last expedition."

III.—THE OPERATIONS WITH THE HAZARA FIELD FORCE.

388. On the completion of the first operations on the Miranzai border, Captain Wahab was appointed Survey Officer with the Hazara Field Force, which was to operate on the Black Mountain. This officer had been attached to the previous campaign there in 1888 in the same capacity, and was therefore specially fitted for the duty. Accompanied by two native surveyors he reached Darband on 6th March 1891. Sub-surveyor Abdul Ghafur was attached to the 2nd Brigade, whilst Captain Wabab and the soldier surveyor accompanied the Head-Quarters and 1st Brigade.

Personnel.

Captain R. A. Wahab, R.E., Deputy Superintendent, 3rd grade, in charge.
Abdul Ghafur, sub-surveyor.
Duffadar Jowala Singh, Guides Cavalry, soldier surveyor.

389. The force advanced across the frontier on 11th March, but little survey work could be done for several days as the detachment with the Tilli column was much hindered by wet and cloudy weather, while the River column was still on ground previously surveyed during the expedition of 1888. On the 21st March the Head-Quarters reached Palosi and remained there till the 8th April. Shortly after arriving there, Captain Wahab considered it desirable to adopt a larger scale for the survey than was at first thought feasible, as it appeared that the operations of the force would probably be confined to the limits of the Hasanzai and Akazai country, instead of being extended over a larger area; and on the 24th the survey was commenced on the scale of 2 inches to a mile, on which scale the whole of the ground covered by the expedition was eventually mapped.

390. On the 28th March, Captain Wahab accompanied a reconnaissance towards Baio, where a large tribal gathering had taken place, and on that and subsequent days succeeded in sketching all the eastern slopes of the Baio range and the approaches to Baio itself. Unfortunately no opportunity occurred of reaching the crest of the ridge which commands an extensive view to the westward over the Chamla and Buner valleys.

391. The 1st Brigade moved from Palosi on the 8th April and marched to Tilli; during the halt there theodolite observations were taken at Tilli and at a point near Pabal Gali to connect the triangulation already done in the Indus valley, with the Great Indian Triangulation, and to fix additional points for the extension of the detail survey further up the Indus.

392. On the 11th April the party marched from Tilli to Rib, and on the 13th to Seri, sketching the country passed over *en route*. While at Seri the survey of the Hasanzai, and upper part of the Akazai country was completed by the 1st Brigade party, the surveyor with the 2nd Brigade working in the meantime in the lower Akazai country around Darbanzai and sketching in all that could be seen of the Chagarzai country. After completing all the survey practicable from Darbanzai, Abdul Ghafur was sent to Pabal Gali to survey the eastern slopes of the Black Mountain towards Tanawal, and to complete the survey of the Indus valley between the frontier and Towara.

393. On the 31st May Captain Wahab moved to Nimal, taking with him the soldier surveyor to survey the crest of the Black Mountain and the slopes towards Agror. The 2-inch survey was continued systematically until the final breaking up of the force on the 14th June.

394. The general results of the survey are as follows :—

(*a*) Theodolite observations have been taken at eight stations, from which their positions and those of 30 other points have been trigonometrically fixed and their heights accurately determined, and from these the heights of a large

* Captain Mackenzie reports that sub-surveyor Hussein Baksh "worked with the utmost zeal throughout."

number of positions, such as villages, river junctions, spurs, &c., have been deduced.

(*b*) An area of 184 square miles has been surveyed on the scale of 2 inches to the mile, a scale large enough to show every hamlet and every feature of importance. This survey includes the whole of the Hasanzai and Akazai country on both sides of the Indus, and parts of the Madakhel and Chagarzai country, as well as a large area on the eastern or British side of the Black Mountain, showing all the lines of communication between Agror and the crest of the range and the Shergarh valley, with the new road between Oghi and Darband.

(*c*) An area of 360 square miles has been sketched on the $\frac{1}{2}$-inch scale. This comprises portions of survey done during the previous expedition which has been thoroughly revised and a considerable area of new country in the Chamla and Itai valleys, west of the Indus, which was sketched from commanding points on the Black Mountain range. There was no possibility of reaching any high point on the range west of the Indus, from which alone any great extension of new work could be made.

(*d*) The survey of the Seri cantonment was made at the request of the Military authorities on the scale of 400 feet to an inch; the area so surveyed being 730 acres or about 1·14 square miles.

395. These results are exceedingly satisfactory and creditable to Captain Wahab, who has, on several previous occasions, rendered excellent services with Military expeditions on the North-West Frontier, and though these services have been invariably brought to notice in Military despatches, he has received no special reward for them. He is an accomplished surveyor in all branches, and has been indefatigable in any duty with which he has been entrusted.*

SPECIAL OPERATIONS ON THE EASTERN FRONTIER OF BURMA.

396. The expeditions, which proceeded to the eastern and north-eastern frontiers of Upper Burma, during the cold weather of 1890-91, were each accompanied by a small survey detachment. Lieutenant Eliott, Assistant Commissioner, with an escort of 70 Gurkhas of the Military Police of the Mogaung levy, started on the 24th of December from Senbo, above the first defile of the Irrawaddy, on his way to the north with the view of exploring the tract of country lying to the north and north-east of the Bhamo District. Major Hobday, with one sub-surveyor and a native soldier-surveyor, accompanied this small column, whilst another sub-surveyor was detailed to accompany an expedition under Lieutenant Burton, which penetrated into the Kachin hills, east of Bhamo. The total area reconnoitred by these two columns amounts to 5,600 square miles, and as this work joins on to Major Hobday's reconnaissance surveys of previous years, further south towards Namkham and Meungmao, a very fair knowledge has been gained of the eastern frontier between the 24th and 26th parallels of north latitude.

397. Another expedition under Lieutenant Daly, Superintendent of the Northern Shan States, started from Lashio on the 21st December 1890, with the object of visiting some of the head villages of the outlying States to the eastward, to ascertain, if possible, the relations between these States with Burma and China. Captain Renny-Tailyour, R.E., and one sub-surveyor, accompanied this party. A sub-surveyor was also attached to a small party under Mr. Saunders, which was to visit the villages in the Taungbaing State and the Kachin country lying near the Chinese frontier to the north of the Theinni State. An area of some 5,250 square miles was reconnoitred during the course of these two expeditions.

398. Mr. Kennedy, Assistant Surveyor, who was on deputation to the Foreign Department, was detailed to accompany the Kyaington-Chiengmai frontier mission under Mr. Archer, British Consul at Zimmé. Two sub-surveyors were also attached to the party, and an area of 9,000 square miles was reconnoitred by this survey party, chiefly of the country lying to the north of that traversed in 1889-90 by the Anglo-Siamese Boundary Commission.

*Captain Wahab has brought to notice the excellent work done by both the native surveyors. Sub-surveyor Abdul Ghafur has done much good work during his long service in the Survey Department, and a great part of it has been spent on the frontier in military surveys.

399. The operations carried on by the parties attached to the different columns will be described separately.

I.—The Operations on the Upper Irrawaddy.

400. The detachment left Bhamo on the 22nd of December 1890, arriving at Senbo the same day, where it joined Lieutenant Eliott and the escort. The march northwards from Senbo was commenced on the 24th of December, and Hokat was reached on the 26th: the road up to this point had been previously traversed, and the country was known. The march was continued on the 28th along the right bank of the Irrawaddy; Myitkyina being reached on the 31st of December, and the confluence of the two main branches of the Irrawaddy (the Malikha and the 'Nmaikha) on the 5th of January; the total distance by land from Bhamo being about 151 miles.

Personnel.

Major J. R. Hobday, S.C., Officiating Deputy Superintendent, 3rd grade, in charge.
Mahomed Sayid, sub-surveyor.

401. Owing to the dense nature of the jungle through which the track lay, it was found impossible to carry on the triangulation, as a wall of primeval forest shut out all view of the surrounding country, and necessitated the cutting of a track for the mules. This difficulty was experienced throughout the march as far as Pumlum Pum, the most northern point reached by the column in latitude 26° 15′.

402. At the bifurcation of the Irrawaddy it was decided to send back the boats which had been bringing up the bulk of the supplies, and to continue the march up the right bank of the Malikha, or western tributary with six weeks' rations carried on mules. Some rough measurements taken here to determine the volumes of the respective branches, gave 33,500 cubic feet per second for the 'Nmaikha or eastern branch, and 23,000 for the Malikha or western branch. These results can only be rough approximations owing to the great rate of the current, from 3 to 5 miles an hour. The temperature of the water in the 'Nmaikha was found to be some 5° to 6° colder than that of the Malikha, from which it may be assumed that the 'Nmaikha receives a greater volume of snow water than the western branch. The Malikha was found to be navigable for boats when the water is low, as far as Sawan, some 24 miles north of the confluence, and probably is so for a much greater distance; whereas the 'Nmaikha is not navigable for any distance owing to a succession of formidable rapids which exist some 6 to 8 miles from the junction. The width of the Malikha at the confluence was found to be 150 yards, and greatest depth of water about 17 feet; the 'Nmaikha being 165 yards wide, with greatest depth of 19 feet. Thus the 'Nmaikha having also the greatest discharge of water, may be entitled to be called the main source of the Irrawaddy.

403. From the bifurcation, the track led into the hills, where between the villages of Paukkaw and Changyang, the main road from Mogaung to the Upper Irrawaddy was met and followed northwards. Seven marches north of the confluence, and at a distance of 57 miles therefrom, a hill known as Pumlum Pum was reached. From here a fine view was obtained: the course of the Malikha was plainly discernible through the low intervening hills almost to the Kanti country, which was reconnoitred by Colonel Woodthorpe, R.E., in his trip there from Assam during 1884-85. Major Hobday was able to map the principal features of the country up to within some 10 or 15 miles of the southernmost parts fixed by Colonel Woodthorpe, and to obtain the names of the principal villages and streams from native information, and has thus been able to connect the surveys from Assam and Burma in a fairly reliable manner. The course of the Malikha is thus fairly accurately known throughout its length. The party was prevented from advancing further northwards by the hostile attitude of the inhabitants all around Pumlum Pum, and in order to avoid an inevitable collision, it was decided to withdraw. The expedition then turned back and retraced its steps as far as Pumwai, whence a different route was taken eastwards to Sabaw on the Malikha, and thence south along its right bank to Kwitao. Here the river was crossed and a track followed which struck the 'Nmaikha at Lekennoi ferry, some 20 miles east of the confluence. From the ferry the column returned in three marches, *vid* Mailompum to Maingna, the most northern Shan village on the left bank of the Irrawaddy.

404. From here, on the 5th of February, the party started on a second trip to endeavour to ascend the 'Nmaikha valley to the north, but the attempt to explore the valley had to be abandoned owing to the passive opposition shown by the Sadan tribe of Kachins at Kwitao and Lakapyang, three marches from Maingna.

405. Thus our knowledge of the sources of the eastern branch is little or no further advanced, and the information that was obtained thereon was so vague as to still leave the matter in the realms of conjecture. On this subject Lieutenant Eliott, who was in political charge of the expedition, gives the following information in his report to the Burma Government:—

"As regards the 'Nmaikha, however, the information to hand is by no means so satisfactory. During our later explorations, the 'Nmaikha was mapped in accurately from the confluence as far as 'Nsentaru, where the river makes a sudden turn to the west after flowing from the north. Above 'Nsentaru, the general direction of the 'Nmaikha as it comes down from the north is known, but the river itself is shortly lost behind high mountains, and north of this any really reliable information is not forthcoming. The old idea was that the river bifurcated some way higher up, and that one of its branches flowed from the Naungsa lake lying to the east. This was the version given by the explorer "Alaga," who was sent up in the year 1880 to try and discover the sources of the Irrawaddy. He, however, only got a very few days inland in the country between the two rivers, when he was turned back by the Kachins. Repeated enquiries made by us failed to get any information worthy the name about the Naungsa lake, and it is very doubtful whether the 'Nmaikha receives any large volume of water from a lake source. It is, however, probable from the information received that a large stream does flow into the 'Nmaikha from the east, at a point several days journey up its course from the confluence. All information about the head-waters of the 'Nmaikha is terribly vague and hazy. The Kachins never seem to go up there, as the country is so wild and bleak. There does not appear to be any trade at all, and the 'Nmaikha, north of 'Nsentaru, probably rapidly degenerates into a furious mountain torrent, dashing through profound gorges, and quite impracticable even for any rafts of the lightest kind. This tract of country seems destined to remain for a long time unknown, as the obstacles to any movement through it to any distance north seem well nigh insuperable.

To ascend the 'Nmaikha, a force of at least 250 men would be required; a base would have to be opened at 'Nsentaru and all rations required north of 'Nsentaru would have to be carried by coolies. Under these circumstances it is not likely that a column would be able to push its way very far. The only practicable way of obtaining any information as to the head-waters of the 'Nmaikha seems to lie in a march across the hills to the east and north-east from the Kanti country. In MacGregor's narrative of Woodthorpe's tour it is laid down that the good will and influence of the leading Kantis would be of the greatest assistance to a column working east, probably as far as the east branch of the Irrawaddy. He says that the natives of Kanti referred to two rivers east of Kanti, called the Nam Tisan and the Phungmai. The Nam Tisan is described as three days' journey from the Kanti country, being separated from the latter by the Tchetpum, and five days more marching to the east, is said to bring one to the Naikôn range (from which silver is extracted), and beyond which flows the Namdumai or Phungmai. There can be no question that this is the 'Nmaikha in its upper reaches. The Kanti Shans expressly called it the east branch of the Irrawaddy, and the great similarity of the names, which (stripped of words signifying stream or water) are Dumai Phungmai, and 'Nmai, tend to show the identity of the river with the unseen east branch of the Irrawaddy. The depth given by the Kanti Shans would also correspond with the probable depth of the 'Nmaikha in that latitude. They describe it as not deep, but not fordable, or somewhat deeper than the Malikha about the same latitude, which was ascertained to be 5 feet, and we know the 'Nmaikha is somewhat the larger river of the two. Besides this the distance from the Kanti country east to the Phungmai, say nine marches, or in a straight line east about 45 miles, would approximately correspond with where the 'Nmaikha valley must be, since the river cannot come further from the east, as the position of the Lukiang or Salween is known in the latitude of Bonga, and also lower down between Bhamo and Talifu, and if the 'Nmaikha falls further east, it will come within what is now regarded as the drainage of the Salween. The Kantis also said there were two more big rivers to be crossed before reaching China, and these would be the Lukiang or Salween and the Lan Ts'ang Kiang or Mèkong. Little doubt can remain now that the Lukiang is identical with the Salween. Colonel Yule in his introduction to "The river of golden sand," by Captain Gill, states that the chief ground for discrediting the length of the course of the Salween and its Thibetan origin was its comparatively small body of water, and adds that this may be due to its restricted basin and all the information we could collect tends to confirm the truth of this reasoning. As far as we know all the water up to within a few miles of the actual Salween falls into the Irrawaddy drainage. It is the vast drainage of the latter river, combining the Malikha, 'Nmaikha, and Chindwin areas that makes it develop so rapidly into a noble river, and the same reasoning will tend to make us look not very far for the sources of the river. It is doubtful if the 'Nmaikha or main stream of the Irrawaddy has any source higher than 28° 30'. Yule calls the east branch of the Irrawaddy in the introductory essay above referred to, the

Tchitom, Schètè, Kuts'kiang, and Khinshi Ho. These are the Thibetan and Chinese names; and as all our information was from purely Kachin sources, we were unable to identify the river under any of the above names."

406. From Lakapyang it was decided to move southwards, exploring the country along the Yunan frontier as far as the Taping river. A considerable area on the frontier was thus traversed and reconnoitred. Bhamo was finally reached on the 15th of April.

407. The area reconnoitred by Major Hobday amounts roughly to 4,300 square miles of previously unexplored country. The Political officer in charge of the expedition has reported as follows on Major Hobday's services therewith :—

"It may seem superfluous for me to remark on the admirable survey work done by Major Hobday of the Survey of India, as that officer has so distinguished himself by his surveys in Upper Burma during the past five years. Marching as we were through a country where the first consideration was the safety of the column, a number of obstacles were thrown in the way of a successful survey, which would have baffled many a man less proficient in his profession, but in spite of all these difficulties, Major Hobday has succeeded in bringing out an elaborate map of an enormous extent of country in the Upper Irrawaddy, of which nothing whatever was previously known."

The Surveyor General fully endorses the opinion expressed of Major Hobday's services in Upper Burma. He has conducted the survey operations therein from their initiation with marked energy and success, and as he has now been transferred therefrom, it is due to him to place on record this appreciation of the valuable services he has rendered during the past five years.

408. Major Hobday's detailed report on the above operations, together with a map, will be found in the appendix.

II.—THE OPERATIONS ON THE EASTERN FRONTIER OF THE NORTHERN SHAN STATES.

409. The survey detachment left Mandalay on the 25th of November 1890, and reached Lashio, the head-quarters of the Superintendent of the Northern Shan States, on the 14th of December. Two expeditions were to start from Lashio; one under Lieutenant Daly to visit the chief villages of the outlying States to the eastward, which lay near the Burmo-Chinese frontier, and to ascertain the nature of the relations which existed between these States with Burma and China, whilst the second expedition under Mr. Saunders was to traverse the North Theinni State and visit the Kachins inhabiting the tracts to the north of this State, as well as to obtain information regarding the Taungbaing State lying directly to the west of North Theinni.

Personnel.

Captain T. F. B. Renny-Tailyour, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Bapu Jadu, sub-surveyor.
Ali Nawaz Khan, sub-surveyor.

410. It was arranged that Captain Renny-Tailyour and sub-surveyor Ali Nawaz should accompany Lieutenant Daly's party, whilst sub-surveyor Bapu Jadu joined Mr. Saunders. Owing to illness, however, Bapu Jadu was unable to start with Mr. Saunders, but joined the party later on in the Taungbaing State in the month of January. Lieutenant Daly's escort consisted of 56 Gurkhas of the Military Police with 50 followers and 30 mules, and, besides the survey detachment, Captain Burrows of the Intelligence Branch and Mr. Warry of the Chinese Consular Service, accompanied the expedition.

411. The party started from Lashio on the 21st of December and marching eastward, reached Meungyaw on the 23rd and Maumak on the 24th. Thence the track turned south-east to Nawngleng, the capital of the Loi-maw subdivision of the South Theinni State. Leaving Nawngleng on the 4th of January, the party reached and crossed the Salween river at Takwi-hpong on the 8th. The crossing here was difficult, the banks being steep and rocky, and the current extremely rapid. The width of the river at this point was some 90 to 100 yards, and its approximate height above sea level 1,300 feet. The Salween was recrossed on the 12th January, and again on the 20th at the Hsupket ferry, at the approximate height above sea level of 1,250 feet. Pangyang, the former capital of the East Mangleun State, was reached on the 26th of January, and during a halt here the Sawbwa paid the camp a visit, coming from his new capital

of Takeut, some 8 miles from Pangyang. Here Captain Renny-Tailyour and Ali Nawaz Khan made a trip of some 20 miles along the Pemeung range, from which a considerable amount of country was mapped.

412. On arriving on the 10th of February at Meung-nga in the Meunglem State, the party found fighting going on between the latter State and East Mangleun, and the villages around Meung-nga deserted. Peace, however, was restored and the villages re-inhabited within a few days of the arrival of the column. After halting two days at Meung-nga, the march eastwards was resumed, and Meunglem, the capital of the State of that name, reached on the 15th February. Leaving again on the 20th, the column passed through hilly and very scantily populated country to Meungse, which was reached on the 1st of March. Here also fighting was going on between the Meungse Myoza and the Sawbwa of Kenghung, a large State lying to the east, the centre of hostilities being some three miles from Meungse.

413. Marching thence, Meunghai was reached on the 6th, and here the main body of the Kyaington-Chiengmai mission, under Mr. Scott, was met. Leaving Mr. Scott's party at Meunghai, the column started again on the 10th of March, and on the 12th arrived at Kenghung, the capital of the State, a wretched town, considering the size of the State, situated on the right bank of the Cambodia (or Mekong) river.

414. The column left Kenghung on the 15th of March, and following a new route, on the return journey, reached Meungma in Kengtung State on the 22nd. From Meungma the track led north-west, until on the 28th the old route was met at Meungma in Meunglem State. From Meungma the column marched to Pang-hsang, a village on the right bank of the Namkha, not far from Meung-nga, where the fighting had been going on on the occasion of the first visit. From here a new route was followed due north to Panglong, passing partly through the Wa country; Pangkwawn, the capital of the Sumu State, was reached on the 15th of April, and Panglong on the 17th. Leaving this place on the 20th, the column camped at Namhu, five miles from the Kunlong ferry on the Salween on the 21st. From here a visit was made to Tunyeo, the capital of the Kokang sub-division of North Theinni State, where the column halted for two days. The Salween was crossed at an elevation of a little under 1,500 feet on the 27th of April, and after joining the Meungse-Theinni road at Yungmaw, the party arrived at Theinni on the 4th of May. Lashio was reached on the 7th, and Mandalay on the 22nd of May.

415. The geographical results of the expedition comprise an area of about 4,000 square miles of country mapped on the $\frac{1}{4}$-inch scale and based on triangulation. To this has to be added an area of 1,250 square miles, mapped on the same scale by sub-surveyor Bapu Jadu in Taungbaing State, whilst accompanying the expedition under Mr. Saunders. The whole of the tract thus surveyed was previously unknown, and much credit is due to Captain Renny-Tailyour and his subordinates for the large and satisfactory results obtained.

416. Captain Renny-Tailyour's report on the above operations will be found in the appendix.

III.—THE OPERATIONS WITH THE KYAINGTÓN-CHIENGMAI FRONTIER MISSION.

417. The survey party, attached to Mr. Archer's frontier mission, proceeded early in November 1890 from Meiktila Road Station to Fort Stedman, and thence, after a short halt to arrange for an escort, to Moné, the most eastern post of the Shan States. Mr. Archer joined the expedition at Mongtun from Zimmé. As a route-traverse had been run the previous year by Captain Jackson from Mongtun, north-east to Maingthat, Mr. Kennedy struck eastwards to visit Loi-pakulin, the last of the trigonometrical stations visited by the Anglo-Siamese boundary party in the previous season. Having observed here he descended to Tongtun on the northern side of the hill, and after a long march rejoined the main body at Maingthat. Here one

Personnel.

Mr. J. M. Kennedy, Assistant Surveyor, 1st grade, in charge.
Mohamed Hussein, sub-surveyor.
Abdul Rahim, sub-surveyor.

sub-surveyor was sent southwards into the hills to sketch the country in that direction, while the other went south-eastward to Hongluk on the Me-huok, and thence south-west to Wiengkhé, a village at the north-east end of the Muang-fang valley. Meanwhile Mr. Kennedy worked in a north-easterly direction up the Mekôk valley, returning again to Maingthat before the main body had moved.

418. The Mekôk river was crossed on the 31st of December, and the party marched down the east bank through heavy jungle to Hweha, a day's march north of Wiengkhé. From Hweha Mr. Kennedy ascended Loi-paham-pup (7,500 feet), the highest of the hills west of the Mekôk. After observing here he descended to Muang-fang, marching thence to Wiengkhé, and so, with one sub-surveyor, across the hills to Hongluk. The other sub-surveyor worked down the river to Kainghai with the main body under Mr. Archer, and thence by an easy road rejoined Mr. Kennedy at Hongluk. From here he was sent to the westward to sketch carefully the course of the Mekham river, which he completed up to its source, returning subsequently to Hongluk.

419. The party then proceeded in a north-easterly direction to Meunglen and struck the Mekong again at Kyanglah. From this place Mahomed Hussein was sent back *vid* Meunglen to Kyaington to work through the hills and await the arrival of the party at the latter place, whilst Abdul Rahim proceeded northward to Mongyu. From Mongyu he was to turn across the hills eastward to Mongsin, whilst Mr. Kennedy accompanied the main body to Mongsin by the Namma valley. From Mongsin Mr. Archer proceeded in a north-easterly direction with the other officers attached to the mission, and Mr. Kennedy, with sub-surveyor Abdul Rahim, went westward towards Kyaington. They followed different tracks as far as Mongyu, where they united after sketching in a large extent of country on both banks of the Mekong. Kyaington was reached some four or five days before the arrival of the main body, now in charge of Mr. Scott, as Mr. Archer had left the party some two days march from Mongsin and had proceeded by a different route. From Kyaington the party proceeded westward, the return march being commenced on the 29th of March. Mr. Kennedy reached Rangoon early in May 1891.

420. The total area reconnoitred on the 1-inch scale amounts to 9,000 square miles, and is in continuation of the work executed in the previous season by the Anglo-Siamese Boundary Commission Survey. The mapping thereof has been prepared in two special sheets, and these with an additional sheet to the north embracing the more important of Captain Renny-Tailyour's survey which adjoins, form a connected series with those of the previous year's work along the entire length of the Upper Burma-Siam frontier. Mr. Kennedy has maintained his well-earned reputation as a surveyor and draftsman by the results of his labours with the Kyaington-Chengmai mission; the out-turn accomplished is a very large one. Further details will be found in an extract from Mr. Kennedy's report in the appendix.

Summary of the out-turn of work of the

Scale of Survey.	Number of Party.	Locale of Field Operations.	Instrument used.	Area triangulated in square miles.	Number of stations at which observations were taken.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Secondary—in which each angle is usually observed on two zeros.				Tertiary—in which two angles of each triangle are observed.			
								Number of stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	Number of intersected points fixed.	Number of triangles.	Error per mile in feet.	Number of heights.
			TRIANGULATION.												
32 inches=1 mile	5	Rampur City	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Garhwal	...	...	...	...	...	...	...	...	...	...	...	...	...	...
16 inches=1 mile	2	Chittagong	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Tipperah (Serail)	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	3	Mandalay	5	...	...	...	...	...	...	...	...	...	...	...	...	...
		Meiktila	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Sagaing	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	4	Jalpaiguri	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	5	Rampur State	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	6	Nowgong	10	...	...	...	...	...	...	...	...	...	...	...	...	...
		Kamrup	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Darrang	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Sylhet	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	7	Thongwa	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Amherst	15	...	...	...	...	...	...	...	...	...	...	...	...	...
	8	Pooree	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Cuttack	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	9	Mandla	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	12	Hanthawaddy	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Tharrawaddy	20	...	...	...	...	...	...	...	...	...	...	...	...	...
		Henzada	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Prome	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	17	Bombay (Forest)	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Detachment	Burdwan	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Beerbhoom	25	...	...	...	...	...	...	...	...	...	...	...	...	...
8 inches=1 mile	17	Bombay (Forest)	7″ & 6″	340	49	7·9	7·9	35	57	9	0·5	35	12	18	1·5	11
4 inches=1 mile	Detacht.	Indus Riverain	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	4	Jalpaiguri (Forest)	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		,, (Waste Land)	6″	19	26	...	...	26	53	19	0·8	...	54	80	0·9	...
	5	Lansdowne (Forest)	7″	35	10	...	...	42	56	...	...	41	...	...	...	769(*f*)
	7	Thongwa	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	14	Hoshangabad (Forest)	7″ & 6″	499	87	0·7	0·7	47	133	14	0·5	71	618	1,096	0·8	618
	17	Bombay (Forest)	7″	179	95	1·6	1·6	58	128	11	0·5	58	121	236	0·7	121
	18	Himalayas	12″ & 7″	476	125	0·7	0·7	93	200	11	0·5	93	534	753	1·0	394
	19	Madras (Forest)	6″ & 5″	950	175	2·2	2·2	164	386	17	0·4	161	350	741	0·9	347
	20	Lower Burma (Forest)	6″	220	5	44·0	44·0	3	3	13	...	5	...	...	...	...
2 inches=1 mile	2	Chittagong	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	10	Gujarat	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		South Maratha country	7″	1,440	45	...	...	45	59	12	0·4	45	14	341	0·4	141
	15	Baluchistan	5″	60	7	1·5	1·7	8	18	14	0·4	8	31	52	1·8	27
	18	Himalayas	12″ & 7″	970	101	1·3	1·3	79	241	14	0·4	73	653	581	0·7	410
	20	Lower Burma	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Detacht.	Black Mountain country	6″	...	12	...	...	10	24	10	1·1	10	31	60	...	30
1 inch = 1 mile	10	Gujarat and Rajputana	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	13	Mergui	45	...	...	...	...	...	...	...	...	...	...	...	...	...
	18	Himalayas	...	...	...	...	...	2	...	...	...	...	...	...	...	...
	Detacht.	Miranzai border	5″	...	4	...	...	...	4	13	0·4	3	12	16	0·8	12
½ inch = 1 mile	10	Guiarat and Rajputana	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	15	Baluchistan	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Zhob Valley	50	...	...	...	...	...	...	...	...	...	...	...	...	...
	Detacht.	Miranzai border	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Do.	Black Mountain country	...	...	...	...	...	...	...	...	...	...	...	...	...	...
¼ inch = 1 mile	11	Upper Burma	6″	12,470	...	...	...	...	...	...	...	...	...	...	...	...
	15	Baluchistan	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Zhob Valley	55	...	...	...	...	...	...	...	...	...	...	...	...	...
	21	Upper Burma	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Detacht.	Upper Irrawaddy	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Do.	Eastern Frontier, Burma	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Do.	Kyaington-Chiengmai frontier	...	...	...	...	...	...	...	...	...	...	...	...	...	...
⅛ inch = 1 mile	15	Persia	60	...	...	...	...	...	...	...	...	...	...	...	...	...
	15	Baluchistan	14″	960	9	107	...	...	...	...	...	...	...	...	...	...
	18	Bhutan snow peaks	7″	...	...	...	...	...	...	...	...	...	150	176	0·7	150
	24	Upper Burma	12* (new)	900	9	...	...	...	...	...	...	...	...	...	...	...
	25	Bombay and Central Provinces	64	...	...	...	...	...	...	...	...	...	...	...	...	...
		Totals	...	19,503	759	...	...	612	1,362	...	...	603	2,583	4,150	...	3,030

Field Parties during the year 1890-91.

SPIRIT-LEVELLING OPERATIONS.				TRAVERSING.					TOPOGRAPHY.						REMARKS.
Number of miles levelled over.	Number of permanent bench-mark stones imbedded.	Number of Trigonometrical stations connected with lines of levels.	Number of permanent points fixed as bench-marks.	Number of stations at which theodolite was set up.	Linear miles.	Average angular error per station in seconds.	Average linear error per *mille*.	Square miles of village survey.	Area in square miles.	Average number of plane-table fixings per square mile.	Number of linear miles of test lines.	Number of villages.	Number of fields.	Average size of field in acres.	
...	...	...	...	2,189	...	...	...	...	2·6	...	...	...	...	...	
...	...	...	...	17,658	4,366	...	...	845	189	...	1,226	1,054	770,804	0·11	
...	...	...	...	27,644	2,479	3	·4	806	460(*b*)	...	902	505	1650,875	0·13(*a*)	(*a*) Calculated on the cultivated portion only.
5 ...	...	...	...	62	20	...	...	...	23	...	23	16	20,351	0·72	
...	...	...	...	7,765	2,007	} 10	·5	389	584	...	792	183	424,247	0·89	
...	...	...	...	10,035	1,744			575	563	...	851	642	376,925	0·95	(*b*) Includes 120 square miles of skeleton survey of jungle lands.
...	...	...	...	10,512	1,370			714	...	...	...	...	...	...	
...	...	...	...	2,013	307	4	·4	67	234	...	429	...	158,718	0·94	
...	...	...	...	8,959	1,250	3	·4	213	721	...	3,135	992	527,249	0·88	
10 ...	...	...	...	4,877	898	4	·6	270	414	...	1,342	501	73,752	3·38	(*c*) Inclusive of 9 River blocks.
...	...	...	...	5,526	1,138	4	·3	394	365	...	1,541	451	88,644	2·63	
...	...	...	...	3,299	752	3	·4	236	2	...	2	2	336	4·66	
...	...	...	...	4,085	392	4	·6	116	47	...	101	46	18,398	1·63	(*d*) Inclusive of 3 Forest and 7 River blocks.
...	...	...	...	16,208	2,995	4	·4	13	320	...	635	175	133,000	0·95(*a*)	
15 ...	...	...	...					814	498	...	977	268	370,632	0·48(*a*)	
...	...	...	...	12,516	2,049	1	·4	481	366	...	1,224	823	667,487	0·35	(*e*) Inclusive of 5 Forest blocks.
...	...	...	...	13,039	2,203	...	·5	501	321	...	2,543	863	485,691	0·42	
...	...	...	...	45,521	8,269	6	·2	3,229	...	...	...	1,214	...	...	(*f*) Determined by clinometer.
...	...	...	...	779	229	...	·2	74	...	...	...	52	...	...	
20 ...	...	...	...	2,365	365	5	·2	114	...	...	...	125(*c*)	...	...	
...	...	...	...	9,138	964	5	·3	510	...	...	...	210(*d*)	...	...	(*g*) Tested *in situ*.
...	...	...	...	14,655	1,372	6	·5	656	...	...	...	366(*e*)	...	...	
...	...	...	...	...	...	..	...	...	22	3·5	37	...	...	...	
...	...	...	...	...	...	...	...	...	4	...	...	89	7,091	0·35	(*h*) These include the bench-marks at Tidal stations.
25 ...	...	...	...	...	...	...	...	...	0·4	...	...	10	934	0·28	
...	...	...	...	6,732	870	8	0·8	...	393	1·77	196	...	...	...	
...	...	...	...	2,826	893	4	·3	743	552	13	52	74	...	...	
...	...	...	...	2,012	226	1	·4	182	174	89	59	...	...	...	
...	...	...	...	2,131	340	1	·4	172	56	44	13	...	...	...	
30 ...	...	...	...	...	...	...	...	...	35	...	...	...	...	...	
...	...	...	...	...	...	...	...	94	164	...	5	71	...	...	
...	...	...	...	4,535	600	7	·2	...	461	1·19	249	...	...	...	
...	...	...	...	134	26	12	0·9	...	124	1·13	22	...	...	...	
...	...	...	...	...	...	...	...	...	272	49	(*g*)	...	...	...	
35 ...	...	...	...	5,208	266	24	3·4	...	465	28	(*g*)	...	...	...	
...	...	...	...	7,387	340	5	6·6	...	167	1·81	36	...	...	...	
...	...	...	...	...	...	...	...	...	82	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	1,083	1·8	209	...	...	...	
...	...	...	...	3,477	1,226	8	·7	...	1,639	1·2	200	...	...	...	
40 ...	...	...	...	...	...	...	...	...	77	8	...	...	...	...	
...	...	...	...	...	...	...	...	...	458	2·2	(*g*)	...	...	...	
...	...	...	...	...	...	...	...	...	204	4·5	59	...	...	...	
...	...	...	...	...	...	...	...	...	184	...	(*g*)	...	...	...	
...	...	...	...	...	...	...	...	...	896	6	93	...	...	...	
45 ...	...	...	...	...	...	...	...	...	930	4	...	47	...	...	
...	...	...	...	...	...	...	...	...	254	1·4	...	...	...	...	
...	...	...	...	...	...	...	...	...	278	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	925	2	59	...	...	...	
...	...	...	...	...	...	...	...	...	380	0·7	...	...	...	...	
50 ...	...	...	...	...	...	...	...	...	1,359	0·3	...	...	...	...	
...	...	...	...	...	...	...	...	...	20	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	360	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	11,964	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	23,500	...	...	...	...	...	
55 ...	...	...	...	...	...	...	...	...	5,004	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	11,330	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	4,300	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	5,250	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	9,000	...	...	...	...	...	
60 ...	...	...	...	...	...	...	...	...	30,500	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	} Trigonometrical operations only.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
64 425	55(*h*)	3	392(*h*)	...	...	...	...	...	...	...	...	...	...	...	
425	55	3	392	253,287	39,956	...	...	12,218	1,17,915	...	16,032	8,819	5,775,134	...	

Statement showing the cost rates of work executed by the

Number of Party.	Nature and *locale* of Field Operations.	Cost-rate per square mile in Rupees.								
		Triangulation.	Traversing.	Detail Survey on Scales of						
				½″	1″	2″	4″	8″	16″	32″
	Topographical Surveys.									
2	Chittagong	...	...	...	...	22·3	...	...	54·8(*a*)	...
4	Jalpaiguri	...	49·2	...	...	...	33·4	...	...	...
10	Southern Maratha country	5·0	2·1	...	...	10·4	...	...	...	...
	Gujarat and Rajputana	2·9	...			3·6 21·0		...	...	...
13	Mergui	...	...	...	140·7	...	...	...	...	...
15	Baluchistan	2·2	...	10·1	...	113·8	...	...	...	...
18	Himalayas	7·0	...	...	15·0	...	...	...	...	...
		13·7	...	...	...	39·3	...	...	...	...
		14·6	...	...	...	...	71·6	...	...	...
Det.	Indus riverain	...	11·1	...	...	...	12·4	...	...	...
	Forest Surveys.									
4	Jalpaiguri	...	49·2	...	...	...	83·2	...	...	...
5	Lansdowne (Garhwal)	...	...	...	...	...	86·7	...	...	...
14	Hoshangabad	28·7	15·4	...	...	...	125·5	...	...	...
17	Bombay — Northern Circle	2·1	23·0	...	...	...	87·2	...	...	...
		...	24·2	...	...	...	...	143·4	...	...
	Southern Circle	...	...	...	...	...	...	...	193·3	...
		10·7	13·0	...	...	...	...	88·2	...	...
19	Madras	20·9		...	...	...	81·3	...	...	...
20	Lower Burma	58·2	160·6	...	...	71·5	178·0	...	...	...
	Cadastral Surveys.									
2	Chittagong	...	50·6	...	...	...	...	...	130·6	...
	Tipperah (Serail)	...	...	...	...	...	...	...	151·5	...
3	Mandalay	...	43·5	...	...	...	...	...	120·7	...
	Meiktila	...		...	...	...	...	...	123·9	...
4	Jalpaiguri	...	49·2	...	...	...	...	...	176·1	...
5	Garhwal	...	32·8	...	...	...	...	...	...	282·6
	Rampur State	...	26·9	...	...	...	...	...	70·1(*g*)	...
6	Kamrup, Nowgong, Darrang	...	29·8	...	...	...	...	...	38·8(*g*)	...
	Sylhet	...	44·5	...	...	...	...	...	39·0(*g*)	...
7	Thongwa	...	46·8	...	...	...	21·7	...	120·2	...
	Amherst	...	55·8	...	...	...	...	...	142·6	...
8	Pooree	...	34·1	...	...	...	...	...	68·5(*g*)	...
	Cuttack	...	34·4	...	...	...	...	...	76·6(*g*)	...
	Traverse Surveys.									
9	Mandla	...	18·8	...	...	...	...	...	...	...
12	Lower Burma	...	60·7	...	...	...	...	...	...	...

several Field Parties during the year 1890-91.

Rate in annas for traversing, detail survey, and preparation of maps.		Cost-rates.					Total cost exclusive of charges for Instruments.	Remarks.
Scale 16″ = 1 mile.		Stone embedding.	Records (*Khanapuri*).		Compilation of Vernacular records, Assessment statistics, etc.			
Per acre.	Per field.	Per square mile.	Per square mile.	Per field.	Per square mile.	Per field.		
a. p.	*a. p.*	*R*	*R*	*a. p*	*R*	*a. p.*	*R*	
...	...	...	...	...	...	...	8,406	(*a*) Skeleton survey of jungle lands.
...	...	...	...	...	...	...	10,835	(*b*) Includes R1,457 expended in bringing up arrears and General Reports; and R13,183 on 1 and 2-inch mapping.
...	...	...	...	...	...	...	73,477 (*b*)	(*c*) Includes R20,994, cost of steam-launch.
...	...	...	...	...	...	...		(*d*) Includes R12,838 expended on the first class triangulation.
...	...	...	...	...	...	...	1,30,790 (*c*)	(*e*) Includes R2,539, expended on Trans-frontier survey; R1,770 on plots of traverses for settlement survey; R1,894 on instruction of soldier surveyors; R4,328 on survey schools; and R797, on revisionary boundary survey.
...	...	...	...	...	...	...	97,224 (*d*)	
...	...	...	...	...	...	...	29,887 (*e*)	
...	...	...	...	...	...	...		
...	...	...	...	...	...	...		
...	...	...	...	...	...	...	17,765 (*f*)	(*f*) Includes R164 expended on the Rewari Municipality; R395 on atlas reduction; R1,908 on completion of previous season's records; and R762, on 2-inch mapping.
								(*g*) Includes R4,609 expended in classification of forests and soils of 461 square miles; and R1,567, in the survey of 150 linear miles of boundary.
								(*h*) Includes charges on account of instruments.
								(*i*) Includes cost of demarcation.
...	...	5·8	...	...	...	...	21,962	(*j*) Includes R722 and R2,168 expended on completion of cadastral maps and records of Wards and Government estate, respectively, in *pargana* Shahaspore, district Backergunge.
...	...	...	...	...	...	...	3,007	
...	...	...	...	...	...	...	84,733 (*g*)	
...	...	...	...	...	...	...		
...	...	...	...	...	...	...		(*k*) Includes R1,016 for connecting Lambhusara G. T. S. with main circuit No. 1 of office work.
...	...	...	...	...	...	...	66,274	
...	...	...	...	...	...	...		(*l*) Includes R11,972 expended on demarcation, and R858 on 2-inch mapping.
...	...	...	...	...	...	...	75,492 (*h*)	(*m*) Includes R5,685 expended on completion of records of previous years; R17,501 on statistics; R1,790 on revision work; R116 instruction in surveying; R3,339 on 2-inch mapping; R6,886 on Bhutan boundary; R233 on Kuch Behar and Jalpaiguri boundary.
...	...	...	...	...	...	...	97,284	
								(*n*) Includes R1,013 expended on repairing stations in the Gursari estates and on revision work in Lalitpur; R1,515 in giving instruction to junior civilians; R8,747 on 2 and 4-inch mapping; and R9,101 Lieutenant Crichton's pay, etc., while under training.
6 6	0 10	7·3 (*i*)	...	...	...	...	1,27,024 (*j*)	(*o*) Includes cost of Rampur city survey on 32-inch scale.
5 5	3 10	...	71·6	1 3	...	...	27,409 (*k*)	
4 5	3 11	...	...	...	10·2	0 3	2,51,457 (*l*)	(*p*) Includes R1,780 revision work in Sibsagar; R5,445 completion of cadastral maps and records; R1,264 instruction to *mandals* in surveying; and R2,854 on 2-inch mapping.
4 6	4 3	...	...	...	10·6	0 4		
8 3	7 9	5·8	39·8	0 7	...	...	4,19,737 (*m*)	
7 11	0 10	...	...	...	...	...	1,01,553 (*n*)	
2 5	2 1	...	(*r*)	...	...	...	56,510 (*o*)	(*q*) The low rate is due to the employment of local agency in lieu of imported *amins* for the field survey.
1 11	5 11	...	...	...	22·0	1 8	85,696 (*p*)	
2 1	3 5	...	...	...	22·7	0 11	10,003	(*r*) The cost rate R70·1 under the head of detail survey, includes both the cost of Cadastral Survey and *Khanapuri*.
4 2	6 5	...	...	...	...	...	51,215 (*s*)	
4 11	3 5	...	...	...	...	...	1,09,197 (*s*)	(*s*) Includes R1,389 expended on revision work; R2,838 on 2-inch mapping; R5,508 on demarcation in district Amherst.
4 0	1 4	6·8	26·4	0 3	2·0	...	79,082 (*t*)	
3 7	1 6	8·3	27·7	0 3	1·6	...	76,467 (*t*)	(*t*) Includes R789 expended on revision work; R2,955 in giving instruction in surveying; R1,023 on demarcation work in Cuttack; R2,447 on 2-inch mapping; R4,910 on completion of Killa Kanika; and R1,540 on Killa Kujang.
								(*u*) Includes R13,484 expended on revision work in districts Betul and Hoshangabad.
...	...	2·9	...	...	...	...	80,220 (*u*)	(*w*) Includes R3,927 expended on revision work in districts Hanthawaddy and Prome.
...	...	21·7	...	...	...	...	1,16,267 (*w*)	

Particulars of Cadastral Surveys completed since 1889-90.

Districts and States.	Scale of survey.	Number of villages.	Number of fields.	Area surveyed in square miles.	Average size of fields in acres.	Cost exclusive of charge for instruments.	Rate per square mile.			By whom and when surveyed.	Remarks.
							Traverse survey.	Cadastral survey.	Cadastral survey with Record of Rights.		
						R	*R a. p.*	*R a. p.*	*R a. p.*		
Burma.											
Thongwa . . .	16″=1 mile.	1,174	1,262,663	2,910	0·15	5,75,688	64 8 0	129 3 0	...	Col. H. S. Hutchinson and Messrs. F. W. Kelly and C. Wood during 1886-91.	
N.-W. Provinces.											
Rampur State . .	16″=1 mile.	1,093	576,965	790	0·87	75,530	23 1 0	...	72 5 0(*a*)	Col. J. E. Sandeman during 1889-91.	(*a*) Executed principally by *patwari* agency.

Particulars of Traverse Surveys executed for Settlement Department Surveys and completed between the years 1884-90.

Districts.	Number of villages.	Area traversed in square miles.	Cost exclusive of charge for instruments.	Rate per square mile.	By whom and when surveyed.	Remarks.
			₹	₹ a. p.		
Central Provinces.						
Balaghat	699	1,300	31,037	23 14 0	Mr. G. H. Cooke during 1888-89.	
Betul	1,112	2,590	61,202	23 10 1	Messrs. A. D'Souza and G. H. Cooke during 1887-90.	
Bhandara	1,405	3,091	52,478	16 15 8	Mr. G. H. Cooke during 1888-90.	
Chanda	1,921	5,317	90,906	17 1 7	Mr. G. H. Cooke during 1888-90.	
Chhindwara	1,405	2,959	82,501	27 14 1	Col. D. C. Andrew and Mr. W. H. Patterson during 1886-89.	
Damoh	1,428	2,920	86,315	29 8 11	Mr. G. H. Cooke during 1885-87.	
Hoshangabad	1,629	2,998	73,012	24 5 8	Mr. A. D'Souza during 1887-89.	
Jubbulpore	2,534	3,881	1,03,165	26 9 4	Mr. G. H. Cooke during 1885-88.	
Nagpur	2,241	3,838	98,046	25 8 9	Col. W. H. Wilkins during 1887-89.	
Narsinghpur	1,092	1,916	64,830	33 13 4	Mr. E. J. Jackson during 1886-88.	
Nimar	705	1,736	48,250	27 12 8	Mr. W. H. Patterson during 1888-89.	
Raipur	3,451	6,880	2,18,007	31 11 0	Cols. W. H. Wilkins, E. H. Steel and Mr. G. B. Scott during 1885-88.	
Sambalpur	1,158	2,353	98,850	42 0 2	Messrs. P. A. G. Cowley and A. D'Souza during 1884-87.	
Saugor	2,068	4,013	1,14,238	28 7 5	Mr. E. J. Jackson during 1886-89.	
Seoni	1,680	3,261	87,165	26 11 8	Col. D. C. Andrew and Mr. G. H. Cooke during 1886-88.	
Wardha	1,381	2,420	61,750	25 8 3	Col. W. H. Wilkins during 1887-89.	
N.-W. Provinces.						
Lalitpur	756	1,939	34,022	17 8 9	Col. J. E. Sandeman during 1888-90.	

LIBRARY OF THE BOMBAY BRANCH OF THE ROYAL ASIATIC SOCIETY

PART III.

THE OPERATIONS AT THE HEAD-QUARTERS OFFICES.

421. These offices comprise—

(1) The Head-quarters offices at Calcutta.
(2) The Trigonometrical Branch office at Dehra Dun.
(3) The Drawing office at Simla.

A detailed description of the work carried on in each office is given below:—

I.—HEAD-QUARTERS OFFICES, CALCUTTA.

SUPERINTENDENCE, CORRESPONDENCE, AND ACCOUNTS.

Personnel.

Colonel H. R. Thuillier, R.E., Surveyor-General of India.
Lieutenant-Colonel C. Strahan, R.E., Deputy Surveyor-General, in charge Revenue Branch.
Lieutenant-Colonel M. W. Rogers, R.E., Assistant Surveyor-General.
Mr. T. Archdale Pope, Deputy Superintendent, 4th grade, Personal Assistant to the Surveyor-General.
„ T. W. Babonau, Registrar.

Correspondence.

Mr. M. Francis, Head Clerk.
„ C. B. Heysham, Head Clerk, from 1st December 1890 to 30th June 1891.
„ J. F. Burbridge, Head Clerk, from 1st July 1891.
„ J. A. Vallis, Clerk.
„ T. E. Ware, „
Babu Kali Podo Banerji, Clerk, Officiating Head Clerk, to 30th November 1890.
Babu Bani Madhub Banerji, Clerk.
„ Durga Narain Ghose, „
„ Ram Kristo Chunder, „
„ Chuni Lal Dey, „
„ Bheekum Singh, Clerk, to 20th May 1891.
„ Gopal Chunder Dass, Clerk.
„ Raj Kumar Dutt, Clerk, to 1st July 1891.
Mr. E. Bonnaud.
Babu Kali Kristo Chunder,
and 9 others.

Accounts.

Mr. H. H. Fenwick, Head Accountant, to 31st December 1890.
„ C. O. Gray, ditto from 1st January 1891.
Babu Bama Churn Chuckerbutty, Accountant.
„ Raj Krishna Mukerji, „
„ Hem Nath Dutt, „
and five others.

422. The general direction of these offices has remained in the hands of Colonel H. R. Thuillier, R.E., Surveyor-General, throughout the year. The Revenue Branch section was under the superintendence of Lieutenant-Colonel C. Strahan, R.E., and the General and Topographical Branch sections under that of Lieutenant-Colonel M. W. Rogers, R.E.*

* The Assistant Surveyor-General reports as follows:—

Mr. T. W. Babonau, the Registrar, has carried on the general superintendence of the office very satisfactorily. Messrs. Francis, Gray, and J. A. Vallis have also done good work. The clerks have in general given satisfaction and the following are deserving of special mention:—Babus Bani Madhub Banerji, Chuni Lal Dey, Raj Krishna Mukerji, and Kanti Churn Sen.

The Deputy Surveyor-General reports that in the Revenue Branch office, Mr. J. F. Burbridge, who has lately taken over the duties of Head Clerk, is hardworking and painstaking, and promises to become a really efficient clerk. Babus Kali Podo Banerji, and Ram Kristo Chunder have continued to do good work, while Mr. E. Bonnaud and Babu Narendra Nath Mukerji have worked hard and satisfactorily.

DRAWING OFFICE.

423. On the transfer of Major Gore, R.E., to the Himalayan field party early in October 1890, Colonel W. H. Wilkins, S.C., was placed in charge of the Drawing Office, and has retained it during the year. The principal work of the three sections into which the office is divided is reported on separately, and a detailed statement of the work executed in each section will be found in the appendix.

Personnel.

Colonel W. H. Wilkins, S.C., Officiating Assistant Surveyor-General, from 10th October 1890.
Mr. G. A. McGill, Chief Draftsman.
„ S. M. Smylie, Head Draftsman.
„ G. D. Cusson, Draftsman.
„ W. Green, „
„ A. J. Musgrove, „
„ J. R. Adels, „
„ R. C. Sinclair, „
„ A. S. Bateman, „
„ A. J. J. Rodrigues, „
„ E. Dowling, „
„ E. Andrews „

Native Draftsmen.

Babu Harihur Sen,
„ Mohesh Chandra Sen,
Munshi Muttiullah,
Babu Purna Chandra Sen,
„ Gopal Chandra Roy,
„ Tincowry Sen,
and 39 others.

Additional Establishment.

Mr. A. J. James, Draftsman,
and 7 native draftsmen.

Surveyors and Assistant Surveyors on duty.

Mr. H. Keelan, Surveyor, 1st grade, from 17th December 1890.
„ F. Adams, Surveyor, 2nd grade, to 25th April 1891.
„ A. G. Wyatt, Surveyor, 2nd grade.
„ W. C. Price, Surveyor, 3rd grade.
„ E. J. Martin, Assistant Surveyor, 1st grade.
„ C. W. F. Seyers, Assistant Surveyor, 1st grade.
„ W. H. Penrose, Assistant Surveyor, 1st grade, to 10th June 1891.
„ W. Warwick, Assistant Surveyor, 1st grade, from 4th May 1891.
„ W. H. D. Ewing, Assistant Surveyor, 1st grade, from June 9th to September 1891.

SECTION I.—GEOGRAPHICAL DRAWING, AND COMPILATION.

424. This section of the office has been engaged principally on the preparation and publication of the maps of Burma on various scales. Three sheets, Nos. 1, 3, and 6 of the South-East Frontier series, on the scale of 1 inch = 8 miles, have been completed from the latest editions of $\frac{1}{4}$-inch maps supplied by field parties, while sheets Nos. 4 and 5 are in progress. The maps of the expedition to the Upper Irrawaddy in 1889-90 by Major Hobday, of the reconnaissance of the districts on the eastern frontier of the Shan states by Captain Renny-Tailyour, of Mr. Kennedy's survey while accompanying the Kyaington-Chiengmai Frontier mission, and of the survey made with the Anglo-Siamese Boundary Commission in 1888-89, have given considerable and valuable additions to the geographical knowledge of the northern and eastern frontiers. As was the case during the two previous years, the preparation of these maps of Burma has thrown an enormous amount of work on the Drawing Office, for when any fresh information is obtained a new edition is at once put in hand.

425. A second edition of the map of Burma and adjacent countries, on the scale of 1 inch = 32 miles, has been prepared and completed with the latest information available. The hills have been printed in grey, which renders the map clear and legible. The compilation of a new map of Upper Burma, on the scale of 1 inch = 16 miles, has been commenced during the year and is well in progress: it is hoped that the map will be published during the present year. It was found more convenient to re-draw the map entirely than to make additions and corrections to the old one which had already gone through five editions, and the original would no longer bear drawing on its surface. It embraces, moreover, a far larger tract of country than the existing map, as it will extend from the Koladyne river on the west to the Mekong (Cambodia) river on the east.

426. It was mentioned in last year's report that a third edition of the 32-mile map of India was in preparation with extensions to the east and west, so as to include the whole of Burma and Baluchistan. The publication of this map has been delayed, in order that all the new material available in the additional areas might be inserted, and it is expected that it will be published during the first half of 1892.

427. A railway map was prepared for the Director-General of Railways for reduction to half scale or 1 inch = 64 miles, by photozincography. The map contains all the railways completed or in progress up to date, as well as all the

names of stations throughout India and Burma, and will probably be found a useful map for others besides the Railway authorities.

428. A set of maps for a new edition of Aitchison's Treaties required by the Foreign Department was commenced in July. There are twenty in all to be prepared, and of these, four or five, are maps of foreign and little known countries which require to be re-compiled from better and later materials to replace the very meagre and obsolete maps which illustrated the older edition of the work. The progress of these maps is slow, as they have to give way to more urgent work at times.

429. The 8-inch divisional maps of the Province of Bengal have been completed, with the exception of two, *viz.*, Chota Nagpur and Orissa. These maps are being drawn on an enlarged scale for reduction by photozincography, and by this method expedition and neat work are assured.

430. The completion to margin of the various maps of the Central India Agency and of the Central Provinces has involved a large amount of work in this section; during the past year eleven maps of the former and one of the latter have been published, while twenty of the former and one of the latter are in various stages of progress. It was found desirable that, as the various maps along the boundary of one province contained only a small portion of that province, these maps should be drawn to margin and published as a series of complete maps; but this has entailed a considerable amount of labour.

431. The preparation of maps for other departments during the year under review has not decreased, and continues to suspend to a great extent the progress of the regular departmental publications. The demand for maps for every conceivable purpose has increased enormously amongst officials throughout India, and the work of the Drawing Office is now more than can be carried out with the existing staff of draftsmen, which was fixed at its present strength many years ago. The increasing pressure demands a larger staff to cope with the present day requirements, and it is intended to represent the matter to the Government of India with a view of a larger establishment being sanctioned.

SECTION II.—REVENUE.

432. The ordinary routine work of this section consists in examining and preparing for photozincography the fair maps received from the field parties of the Revenue Branch, in bringing up to date and republishing old maps, and in supplying data. Besides this regular work the fair topographical sheets, on the 2-inch scale, of districts Ferozepore, Umballa, and Hissar in the Punjab, were completed up to margin. The additions were obtained from the 4-inch and 2-inch surveys of the late district of Sirsa, district Karnal, and Sikh States, as well as from the adjoining district of Saharanpore in the North-West Provinces.

433. A map of the Punjab, on the scale of 8 miles to the inch, for reproduction to scale, showing the *reh* (alkaline earth) affected localities, was drawn for the Revenue and Agricultural Department and sent to press, and proofs are now under correction. A skeleton map, on the scale of 4 miles = 1 inch, of districts Garhwal and Kumaun was prepared for His Excellency the Viceroy. The old map of the city of Calcutta, on the scale of 6 inches = 1 mile, was, as far as practicable, brought up to date, and information regarding new postal and police stations was inserted. The new docks at Kidderpore have also been added, as well as fresh topography in the suburb of Ballygunj.

434. The district map of Raipur, Central Provinces, on the scale of 2 miles = 1 inch, has been passed through the press, and the proof is now under correction. In the North-West Provinces the ½-inch district map of Ghazipur has been published; that of Benares is under publication, and the map of district Basti will shortly be sent to press; the maps of districts Gorakhpur and Mirzapur are in progress.

435. The computing establishment attached to this section has as usual been engaged on a great amount of miscellaneous work for other departments, and the arrears in the examination of the records of the field parties have in consequence not lessened. The assistance expected from the field parties, as reported last year, has been of little avail at present, as spare computers could not be obtained therefrom, but it is hoped that help may be obtained in this way

in future. The demands made by other departments for the supply of data have been very great, involving much labour and time; for instance, demands for the areas of the different Native States in Central India and Rajputana, as well as those of the several districts in Assam, were received, which necessitated the calculation by the planimeter of different areas in about 900 sheets. The field records of district Saugor, extending over three years, have only been examined during the year under review. The very large amount of traverse surveys that have been done during the past few years, to furnish a basis for settlement surveys in the Central Provinces, is the main reason for arrears having accumulated. As there were ten field parties employed entirely on this class of work this last year, and as the records of one party for three years could only be examined, it follows that the records of seven parties for one year have been added to the arrears that existed last year.

SECTION III.—CADASTRAL.

436. This section is employed in preparing the original maps of all the cadastral surveys for zincography and photozincography. The method is to examine the numbering of the fields and to observe if all holdings and divisions of land are correctly tabulated in the area statements. The total number of maps passed for publication during the year was 4,710, of which 1,215 were for zincography and 3,495 for photozincography, showing an increase of 303 on the return of the previous year; but of these only 4,449 were actually printed, 3,216 being coloured, examined, and sent for record with the Settlement Officers of the districts to which the maps belonged.

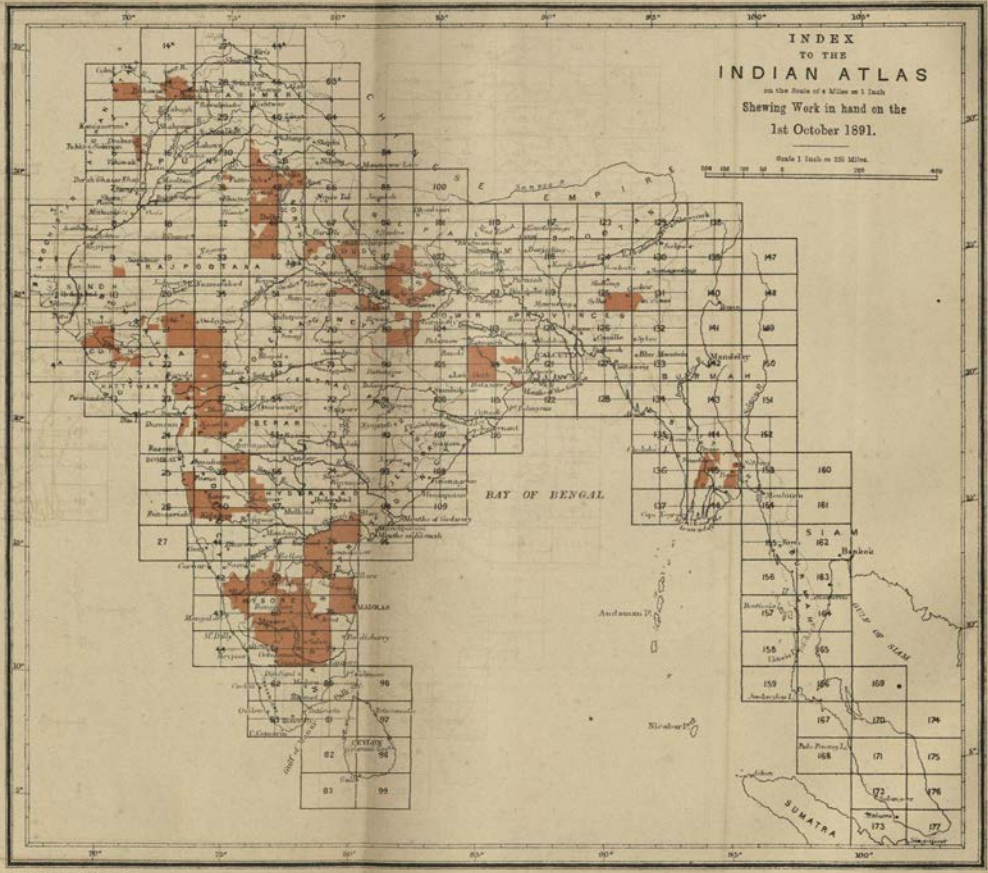
437. The maps completed and published have been arranged and bound into 53 volumes for record in this office, and 44 volumes of printed cadastral maps of district Thongwa, Lower Burma, have been arranged in circles and townships, indexed, examined, and bound, and forwarded to the Chief Commissioner of Burma.

438. In consequence of the urgent demands made for the publication of the cadastral maps of districts Basti and Gorakhpur which have not yet been printed, all reprints of former published maps were stopped from February 1891. The maps of district Basti were completed in May, and it is hoped that the publication of the maps of the Gorakhpur district will be completed by May 1892.

439. The work of examination and preparation of the maps of the current cadastral surveys is greater than can be accomplished with the existing establishment, and it has not been possible to diminish the arrears that have accumulated as reported in the last Annual report. If the printing of cadastral maps is to be continued, it will be necessary to increase the staff of this section. At present the Burma and Assam Governments continue their demands for printed maps.*

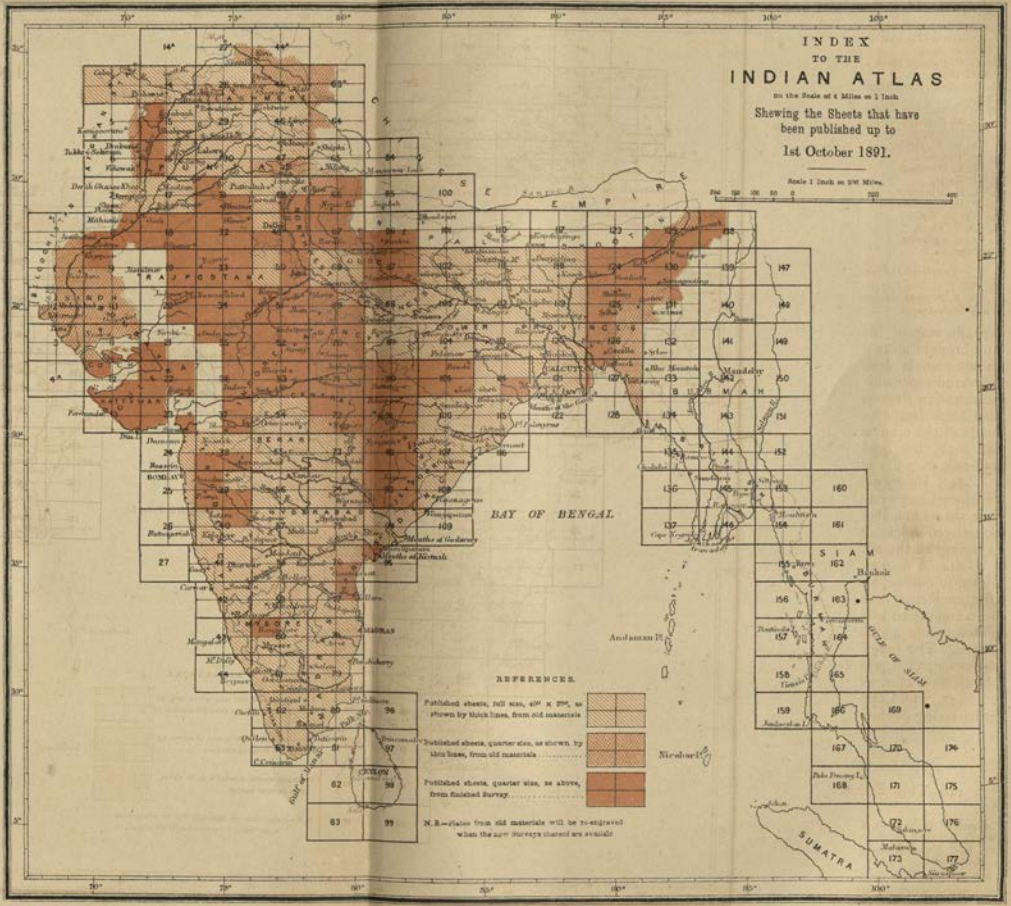
* The Assistant Surveyor General reports as follows regarding the assistants in charge of the three sections:—Mr. McGill, the Chief Draftsman in charge of No. I Section, was in indifferent health for the greater part of the year; but he has discharged his duties well. Mr. Smylie, the Head Draftsman in charge of No. II Section, has again given the greatest satisfaction in the discharge of his duties. Mr. James, in charge of No. III Section, has also done well. Mr. Price was in charge of the Examining Section, which is attached to No. I Section, and rendered efficient service. Of the European and native draftsmen the following are commended:—Messrs. Green, Musgrove, Cusson, Martin, and Penrose, and Babus Mohesh Chandra Sen, Gopal Chandra Roy, Harihur Sen, and Munshi Mutiulla.

Special mention is made of Mr. Sinclair's services, as he is thoroughly acquainted with every detail of the work of No. I Section.



Reg. No. 810. S. I. D.—Nov. 91.—600.

Litho of I. G. Calcutta.



Reg. No. 613. S. I. D.—Nov. 92.—500.

Litho. S. I. O., Calcutta.

ENGRAVING OFFICE.

440. The superintendence of this office is in the hands of the Assistant Surveyor General in charge of the Drawing Office. Mr. G. G. Palmer was Head Engraver till the 23rd April 1891, when he retired on superannuation pension after 18 years of highly approved service and was succeeded by Mr. J. Fulford.

Personnel.

Colonel W. H. Wilkins, S.C., Officiating Assistant Surveyor-General in charge, from 10th October 1890.
Mr. G. G. Palmer, Head Engraver, up to 22nd April 1891.
Mr. J. Fulford, Head Engraver, from 23rd April 1891.
Mr. W. Donaldson, Engraver.
„ S. M. Coard, „
„ T. B. Rodger, „
„ A. W. N. James, „
„ A. R. Coard, „
„ E. C. Ollenbach, „
„ E. Earle, „
„ L. H. Musgrove, „
„ F. R. C. Scallan, „
„ W. M. Wells, „
„ A. T. Vieux, „
22 native engravers.
3 apprentices.

Copper-plate Printing Section.

Mr. W. T. Collins, Copper-plate Printer.
„ A. E. Pilley, Assistant Copper-plate Printer and Store-keeper.

441. The out-turn of work, a summary of which will be found in the appendix, is much the same as last year, the smaller return in outline being fully compensated for by a larger number of letters cut over last year's return; the hill etching is also in excess.

442. The 32-mile map of India, in six plates, is still unfinished; the plates have to be enlarged on the east and west margins to allow of the insertion of additional areas in Burma up to the borders of China and Siam and in Baluchistan, and they are in various stages of advancement. The 64-mile map of India, in 4 sheets, is being corrected as regards orthography, and brought up to date in respect to railways, &c. The 96-mile Railway map in one plate is almost completed. The compilation of this map, which is being engraved especially for the Railway Department as a standard map for their Administration Reports, has been greatly delayed owing to the alterations required by that Department being so heavy as to necessitate a matrix, and a duplicate being made of the original plate. Another map of India, on the scale of 128 miles to the inch, has been projected to replace the original plate thereof, and the new 256-mile map has made fair progress, being about half completed in writing.

443. Heavy corrections and additions have been carried out on the various provincial maps on the scale of 1 inch = 16 miles. The map of the Punjab in four sheets and the map of Mysore have been well advanced, both being nearly completed in lettering, while that of the North-Western Provinces and Oudh is having all the additional material added as far as possible.

444. A map of Darjeeling, on the scale of 1 inch = 4 miles, has been completed in outline, and the lettering is about to be commenced. Of the Administration Report maps, those of Bengal and the Punjab, on the 80-mile scale, have been completed with hills; Assam on the 48-mile scale has been nearly completed, while 43 district maps on various scales are in progress in different stages. The index map to the standard sheets of the Central Provinces has been completed, while many miscellaneous maps, amounting altogether to 240 plates, have been worked upon during the year.

445. The Copper-plate Printing Section pulled 21,000 impressions and the Steel-facing Section dealt with 122 plates.*

CALCUTTA CITY SURVEY OFFICE.

446. This detachment has remained throughout the year under the charge of the Assistant Surveyor General, Drawing Office, Calcutta.

Personnel.

Colonel W. H. Wilkins, S.C., Deputy Superintendent, 1st grade, in charge.
Mr. D. Atkinson, Surveyor, 1st grade.
Mr. A. B. Smart, Assistant Surveyor, 2nd grade.
17 draftsmen.
3 field surveyors.

447. Last year's report recorded the following work as still remaining to be completed:—

(1) The house-to-house enquiry as to names and addresses of proprietors, and the investigations of the boundaries of holdings, of which

* Mr. Palmer supervised the office very efficiently, and on his retirement Mr. Fulford has carried on the duties to the satisfaction of the Assistant Surveyor-General. The European and native engravers are on the whole very favorably reported on.

there are probably 200 remaining in the collectorate and about 2,500 in the Sutanoti *taluk* of Calcutta.

(2) The completion of the original field sheets in colour, which involves many references on the spot, and in some cases re-surveys in consequence of additions or alterations since the original survey was made.

(3) The survey and adjustment of the boundaries of about 1,500 holdings, of which the proprietors were not present at the time of survey.

(4) The completion and publication of 235 fair sheets, all of which are in various stages of completion and are only waiting for the demarcation and insertion of all the boundaries.

(5) The completion of the register of proprietors.

448. The following progress has been made in the above during the year under report :—

(1) In the house-to-house enquiry the estimate of holdings which remained to be completed in Sutanoti *taluk*, was found to be exceeded by 552. It may be mentioned that it was impossible to find out the exact number until a survey was made, as there was no register of any kind available. During the year the demarcation of 2,752 holdings of this *taluk* was completed, leaving about 300 to be dealt with; these could not be done in consequence of the non-attendance of the proprietors.

(2) As regards the completion of the 459 original field sheets in colour, the sheets, 228 in number, of the south division have been nearly finished, and the 231 sheets of the north division will not require much labour, as the field sheets were to a great extent coloured before the demarcation of the boundaries was taken up.

(3) In the survey and adjustment of boundaries, 245 holdings have been completed. Since the house-to-house enquiry as to names and addresses of proprietors was originally made, some of the holdings have changed hands, necessitating the issue of fresh notices which prevented more being accomplished. In the holdings demarcated there were 36 disputed cases. The total number of holdings demarcated since the commencement of the survey is as follows :—

Up to September 30th 1890 . . .	17,401
During 1890-91	2,997
TOTAL .	20,398

It is probable that 1,550 holdings still remain for final demarcation.

(4) Some progress has been made in the completion and publication of the 235 fair sheets, and those containing blocks XI and XII of the south division will be soon forwarded to the Photo. Office for reproduction.

(5) The register of proprietors has been progressed with, and about three-fourths has now been completed.

449. During the year there were 230 disputed boundaries, of which claims were entered for 191 cases which were sent to the Court of the Assistant Superintendent of Survey under the Calcutta Survey Act, Rai Kally Churn Ghose Bahadur. Of these cases 139 were decided and 52 are in course of investigation. The Municipality was involved in 50 cases, of which 29 were decided against it.

450. During the year it was decided to publish the map of Calcutta by the process of heliogravure on the scale of 16-inches to the mile. This map will consist of 15 sheets, and each of these sheets will contain 25 of those on the scale of survey, or 1 inch=50 feet. Two of these sheets are now in hand and will be soon ready for photography.

SPECIMEN OF DIRECT REDUCTION OF TWO SHEETS OF THE NEW SURVEY OF THE CITY OF CALCUTTA

FROM THE SCALE OF 1 INCH=60 FEET TO 1 INCH=330 FEET, OR 16 INCHES=1 MILE

Photoetching.

Survey of India Offices, Calcutta, February 1895.

451. The causes of delay in the completion of the City Survey were explained in para. 468 of last year's report. During the year, prosecutions for non-attendance to point out boundaries, and for evading the summonses to appear before the Assistant Superintendent's Court have been made whenever the defaulters have not shewn sufficient cause for their neglect. Only eleven prosecutions were instituted, and of these ten were successful, fines from R10 to 20 being inflicted. It does not appear that more stringent measures can be enforced to secure better attendance.*

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE.

Personnel.

Colonel J. Waterhouse, S.C., Assistant Surveyor-General, in charge up to 7th May 1891.
Mr. T. A. Pope, Deputy Superintendent, 4th grade, in charge from 8th May.

NEGATIVE SECTION.

Normal Establishment.

Mr. H. Haward, Head Assistant, upto 7th July 1891.
Mr. J. Harrold, Officiating Head Assistant, from 8th July 1891.
Munshi Ismail Khan, Assistant Photographer.
Mr. G. W. Mackie, Assistant Photographer.
Mr. E. Savedra, apprentice.
One assistant photographer and two negative retouchers.

Cadastral Establishment.

Mr. L. Lagnier, Photographer.
„ T. Lloyd, Offg. ditto
„ C. D'Cruze, Assistant Photographer.
Three native assistant photographers and three negative retouchers.

PHOTO-TRANSFER PRINTING SECTION.

Normal Establishment.

Mr. J. Harrold, Photographer, up to 7th July 1891.
Munshi Habeebul Hossain, Assistant Photographer.
Mr. P. C. Michael, Apprentice.

Cadastral Establishment.

Mr. R. George, Photographer, and two assistant photographers.

SILVER-PRINTING SECTION.

Mr. C. J. Meade, Apprentice, and one assistant photographer.

HELIOGRAVURE AND COLLOTYPE SECTION.

Mr. A. W. Turner, Photo-Engraver.
„ P. Mackenzie, Apprentice, up to 31st May, one assistant photographer, two engravers and three copper plate printers.
Mr. J. T. Meade, Collotype Printer.

LITHOGRAPHIC DRAWING SECTION.

Mr. H. L. Lepage, Head Assistant.
Babu Umbica Churn Mookerjee, Examiner.
Munshi Sobhan Baksh and 24 other draftsmen.

ZINC-PRINTING SECTION.

Normal Establishment.

Mr. B. Mackenzie, Zincographer.
„ F. R. Vandyke, ditto.
„ J. B. Mackenzie, Assistant Zincographer, one writer and four zinc correctors.

Cadastral Establishment.

Mr. E. A. LeFranc, Zincographer.
„ G. A. LeFranc, Apprentice, one writer and nine zinc correctors.

LITHO-PRINTING SECTION.

Mr. D. Deas, Head Lithographic Printer.
Mr. S. U. Ravenscroft, Assistant Lithographic Printer.

TYPE PRINTING SECTION.

Mr. E. DePyvah, Head Printer.

CORRESPONDENCE AND ACCOUNTS SECTION.

Normal Establishment.

Mr. W. Moore, Store-keeper.
Babu Kanny Lall Sen, Head Clerk and Accountant.
Babu Gopal Chunder Mookerjee, Clerk, and one other.

Cadastral Establishment.

One Clerk.

LITHOGRAPHIC ESTABLISHMENT.

Babu Russick Lall Shaw, Clerk, up to 6th April 1891.
Babu Nogendra Nath Mookerjee, Clerk, offg. from 7th April 1891.
Babu Rajani Kanto Chatterjee, Clerk, and three others.

452. The office was under the charge of Colonel J. Waterhouse from the commencement of the year under report till the 7th May 1891, when he proceeded to Europe on furlough for six months, and Mr. T. A. Pope took charge and officiated for the remainder of the year. There have been but few changes in the personnel of the establishment during the year, and no casualties among the European assistants.

453. The machinery has continued to work without difficulty during the year, and has been most valuable in getting through the increasing amount of printing work. The hand-presses have also been fully engaged.

454 The generat abstract of work turned out, given in the tabular statement below, again shows a very large increase in all sections over last year's out-turn. The few items in defect, *viz.*, the number of stones transferred and the number of type items set up, and of blue prints, are more than counter-balanced by large increases in the number of zinc plates transferred, in additional pulls from type and a large number of silver prints.

* Mr. D. Atkinson, who was in immediate charge of the detachment, has performed his duties to the entire satisfaction of his superintending officer, and Mr. A. B. Smart is also well reported on. Mr. Atkinson reports very favourably of Rahim Eux, draftsman.

General Abstract of work done during 1890-91.

Classification.	Sheets or Subjects.	Negatives and transparencies.	Photo-zincographic and Lithographic Printing.								Type Printing.			Silver and other Printing.		Heliogravure and Electrotyping.				Photo-collotype.		Value.
			Photo-transfer prints.	Zinc plates transferred.	Zinc plates printed.	Stones.	Pulls.	Number of Copies. Coloured.	Number of Copies. Uncoloured.	Number of Copies. Total.	Pages or items.	Pulls.	Copies.	Silver prints.	Blue prints.	Heliogravure plates.	Heliogravure prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.	R. a. A.
Departmental maps and plans	1,145	1,320	1,276	481	667	109	173,878	16,320	156,612	172,932	9,098	1,074,280	581,690	9	2,403	12	2,134	...	26	...	...	80,987 4 9
Cadastral maps	4,376	3,211	3,257	4,481	4,481	...	151,557	...	142,519	142,519	...	...	...	...	...	...	...	...	...	...	...	65,722 5
Extra Departmental maps and plans	1,546	1,163	1,016	476	460	465	386,513	94,480	350,437	444,917	...	...	...	1,096	288	58	31,831	35	...	...	...	61,944 3 0
Totals	7,067	5,694	5,578	5,441	5,611	573	711,978	110,800	649,568	760,368	9,098	1,074,280	581,690	1,105	2,691	70	34,015	35	26	...	...	2,08,653 12 9
Totals of 1889-90	7,021	5,600	5,148	5,377	5,540	585	598,997	99,053	563,650	662,703	9,918	1,061,577	573,885	179	2,823	56	30,589	6	17	12	3,432	2,00,374 12
Differences	+ 46	+ 94	+ 431	+ 64	+ 71	− 12	+ 112,931	+ 11,747	+ 85,918	+ 97,665	− 820	+ 12,703	+ 7,805	+ 926	− 132	+ 14	+ 3,426	+ 29	+ 9	− 12	− 3,432	+ 8,279 0 3

455. The increase in the number of copies printed off zinc or stone has been general, and the colour printing again shows a very large increase of nearly 12,000 copies. The number of cadastral maps printed shows a falling off of fifteen, but on the other hand, the number of copies printed shows a large increase of 43,165. Of the surveys in the North-Western Provinces 2,308 sheets; of Burma 895 sheets; of Assam 1,173 sheets, were photozincographed or zincographed from tracings. Although there is some falling off in the number of items set up in the type-printing section this year, the number is still very far above the average, and there is an increase of 12,703 in pulls and of 7,805 in copies.

456. The preparation of the third and extended edition of the 32-mile map of India has progressed and the map was nearly completed for issue, but large additions of hill shading have still to be made on the stone of sheet 4, containing Burma, and as these will take some time to draw, the publication of the map will probably be delayed for some months. The conversion of the Military and Railway map of India, on the 32-mile scale into an ordinary departmental publication for general purposes, which was referred to in paragraph 4[illegible]8 of last year's report, has had to be stopped for the present owing to the pressure of more urgent work.

457. Among the statistical maps published may be noted:—Two railway maps of India with hills, on the scales of 48 and 64 miles to the inch; reprints of the railway map of India, on the 32-mile scale, and of India showing telegraphs, on the 96-mile scale, both corrected up to March 31st, 1891. Among the Provincial maps, new issues, with corrections and additions to railways, have been made of:—The Madras Presidency, North-Western Provinces and Oudh, and the Central Provinces, all on the scale of 1 inch = 32 miles; and also of the Presidency and Chittagong divisions, on the scale of 1 inch = 8 miles. Divisional maps of the North-Western Provinces and Oudh, Agra, Meerut, Rohilkhand, Fyzabad, and Lucknow, on the scale of 1 inch = 4 miles, were received for lithography, and some of them are in hand.

458. The following district maps, taken from the engraved plates of the Atlas of India, were lithographed during the year, *viz.*, Rungpore, Cachar, Darrang, Monghyr, Lakhimpur, Chittagong, Dacca, Jalpaiguri, and Singhbhoom; those of Bogra, Sylhet, Goalpara, Dinagepore, Shahabad, and the Naga Hills were transferred but not printed. Maps of district Darjeeling (skeleton), ¼-inch scale, and of districts Lahore, Bilaspur, and Ghazipur, on the ½-inch scale, also a second edition of the map of the Garo Hills, on the same scale, were photo-

zincographed and printed off. A large number of standard sheets, amounting to 481, have been in hand, of which 239 have been published, exclusive of reprints. Among them may be noted 11 sheets of Bengal, districts Patna, Pubna, Monghyr, and Mymensingh; 11 sheets of Bombay, districts Ahmedabad, Belgaum, Dharwar, Mahi Kanta and Poona, all on the 1-inch scale: also 30 sheets of Lower Burma, districts Akyab, Hanthawaddy, Henzada, Pegu, Prome, and Tharrawaddy, on the 1-inch scale, and six quarter-sheets, on the 4-inch scale, districts Prome and Tounghoo; 13 sheets of the Central Provinces, districts Sambalpur, Betul, and Chhindwara; 33 sheets of the North Western-Provinces and Oudh, in districts Basti, Gorakhpur, Mirzapur, Agra, Gonda, Kheri and Bahraich, all on the 1-inch scale, and 3 sheets of Aligarh, Etah and Mainpuri, on the 2-inch scale. Of the North-East Frontier, 1 sheet on the 8-mile scale, and new editions of two sheets on the 4-mile scale. Of the South-East Frontier, 2 sheets on the 8-mile scale, and 15 sheets of new editions of maps already published, on the 4-mile scale; 5 sheets of the Punjab, districts Dera Ismail Khan, Jhang, Bikanir, and Bhakawali, Patiala, and Bhurtpur, on the 1-inch scale, besides, 11 sheets of districts Gurdaspur and Jummoo, on the 6-inch scale. Reprints with additions have been made of 59 sheets of the Madras survey, on the 1-inch scale, including new editions of several sheets of the Mysore survey with corrected boundaries; also of 21 sheets of the Central India and Rajputana surveys.

459. Among the city and cantonment plans published, may be noted a new edition of the plan of the city of Calcutta in two sheets, on the scale of 6 inches to the mile; a plan of the city and environs of Lahore, with the civil station and cantonment of Meean Meer, in six sheets, on the scale of 6 inches = 1 mile. Besides the above a large number of technical charts, index maps, and miscellaneous maps and items have been reproduced on account of the department.

460. A trial was made of reducing the original sheets of the new survey of the city of Calcutta from the scale of 1 inch = 50 feet to that of 16 inches = 1 mile with the object of preparing a map by heliogravure for general purposes. With considerable manipulation good results were obtained in this way, as will be seen from the specimen attached to the report of this survey at page 92. It was found, however, that the sheets were over-charged with many small details, which would have been superfluous and confusing on the smaller scale; and as the removal of these, and other necessary alterations and additions to details and names to render them suitable for the smaller scale, would have involved a large amount of labour on the photographic negatives and copper plates, it was considered desirable to have the sheets re-drawn specially for reduction, and this is now being carried out.

461. The amount of extra departmental work has again been very large. Among the principal items are a military map of India, on the scale of 32 miles to the inch; a forest map of the Punjab, lithographed in colours on the same scale, and a geological map of South Malabar in colours, on the 4-mile scale. A map of the communications in the Bengal Presidency in 17 sheets, on the 1-inch scale was printed off, and 61 sheets of the plan of the city of Mandalay, on the scale of 1 inch = 40 feet, with several maps of the Yenang Yaung and other oil-fields, have been photozincographed for the Chief Commissioner of British Burma. A very large number of maps and drawings have been lithographed and photozincographed for the Director General of Railways. Besides the usual weather charts and diagrams executed for the Meteorological offices, India and Bengal, the illustrations of the new monthly weather report which was started in January last have been taken up; they consist of five full page diagrams, in two printings each, monthly, and their reproduction by lithography has entailed a good deal of work. It is, however, now proposed to reproduce them by photozincography. Fourteen maps of field-firing were drawn, printed, and coloured for the Adjutant General's Office. Maps of 32 districts and plans of 33 civil stations in the Punjab were received for lithography, and most of them have been drawn and printed. The value of the work executed for other departments was ₹61,944·3, or ₹7,994·5 less than last year.

462. The heliogravure section has made good progress during the year, and the out-turn is steadily increasing all round. By the photo-etching process 70 plates have been produced and 34,015 copies printed; 35 photo-blocks have been prepared and 26 plates have been electrotyped, either as matrices or duplicates. The preparation of the plates of the Technical Art series has been

continued during the year, and 21 plates have been reproduced and distributed. Besides these, 17 plates of moths, etc., illustrating the Indian Museum notes on Economic Entomology, were prepared and partly printed, besides 29 half-tone blocks for the same publication which were prepared here and printed with the type at the Government Printing Office. This new branch of work, which is more fully detailed in the appendix, is likely to be very useful, and it is hoped that better results may be obtained by means of some finely ruled gratings received by Colonel Waterhouse from America. Mention may also be made of an illustration for the "Scientific Memoirs by Medical Officers of the Army in India:" this was reproduced on an orthochromatic plate from an original drawing executed in delicate shades of violet, blue, and reddish orange. The copper plate was printed at *one* operation in these three colours as well as in black, as will be seen in the annexed specimen.

463. Owing to Colonel Waterhouse's absence on furlough no further improvements have been made in working out the process of producing reversed positives on dry plates in the camera by means of thio-carbamides in the developing solution, which was reported on last year. Some experiments have been made with other salts of the same kind, but further working is still required to bring the process to a practical issue. Colonel Waterhouse has continued his investigations of the electrical action observed in the development of these reversed images, and has obtained evidence of the existence of distinct and, in some cases, comparatively strong electrical currents generated during the development of ordinary photographic dry plates. It is hoped that further experiment in this direction may throw light on the general theory of development of the invisible photographic image, and also possibly lead to a completely practical reversing process with the thio-carbamides.

464. In the course of his furlough Colonel Waterhouse visited the Ordnance Survey Office, Southampton; the "Institut Cartographique Militaire" at Brussels; the Imperial State Printing Office, Berlin; the "Imprimerie Nationale" and the Photographic section of the Geographical Department of the Ministry of War at Paris, and private establishments at Munich, with a view to obtaining information regarding the printing of copper plates by machinery, the production of half-tone photo-blocks, and other points connected with his work. He found that the various automatic copper-plate printing machines hitherto brought out had universally been found unsatisfactory, but that some gain in speed of printing could be obtained, either by cold printing with a fluid ink and dry paper in a specially powerful press worked by steam as at Southampton, or by the use of D presses worked by steam, which, however, requires the plate to be inked in the usual way by hand. One of the latter presses has been ordered for the office. Beyond several useful hints on various points, no important information could be obtained regarding the block processes which do not appear to be regularly worked at present in any of the Government institutions visited. Further details of these visits and of other technical points connected with the working of the various new processes tried, are given in the appendix.*

* Colonel Waterhouse reports well of the conduct and satisfactory carrying on of their duties by his principal assistants: Mr. H. L. Lepage, Mr. B. Mackenzie, Mr. D. Deas, Mr. E. A. LeFranc, Sergeant Vandyke and Mr. E dePyvah in the Printing sections; Messrs. H. Haward, J. Harrold, R. George, L. Lagnier, and W. Moore in the Photographic sections. Among the assistants and apprentices are mentioned Messrs. S U Ravenscroft, G. A. LeFranc, J. T. Meade, and C. J. Meade, G. Mackie P. Michael, and J. Makenzie, who have all worked satisfactorily. In the Lithographic sections the draftsmen have all worked well. Babu Umbica Churn Mookerjee and Munshi Abdul Hamid are specially mentioned. Babu Kali Podo Dass, a very promising young draftsman, died in May last and his loss has been very much felt. The clerks are also well reported on, specially Babu Kanny Sen, Head Clerk and Accountant, Babus Gopal Chunder Mookerjee, Kedar Nath Ghose, Rajani Kanto Chatterjee and Surji Kumar Banerjee. Babu Rassik Lal Shaw died in April last after a service of 24 years in the Lithographic Office: he was a very steady, hardworking man, well up in his work, and his loss also will be much felt. Shama Churn Chukerbutty, paper-keeper, had to retire on invalid pension. In the Photographic section the native assistants have done good work, especially Mahomed Ismail, Habeebul Hossain, Abdul Rahman, Umbica Churn Bhattacherjee, and Preonath Chatterjee.

SPECIMEN OF ORTHO-CHROMATIC REPRODUCTION FROM A COLOURED DRAWING AND OF COLOUR-PRINTING IN 4 TINTS FROM ONE COPPER-PLATE.

Fig 1 x160.

Fig 2 x160.

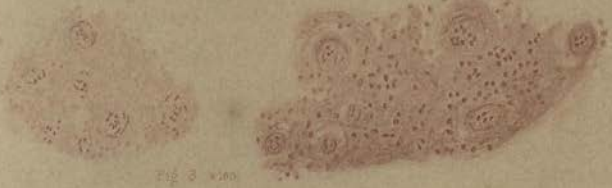


Fig 3 x160.

Fig 4 x37

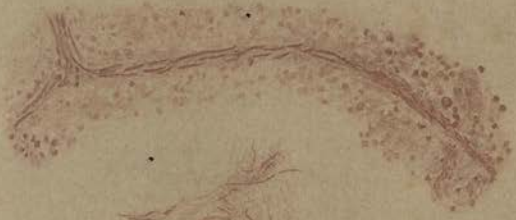


Fig 5 x160.

Fig 7 x160.

Fig 6 x160.

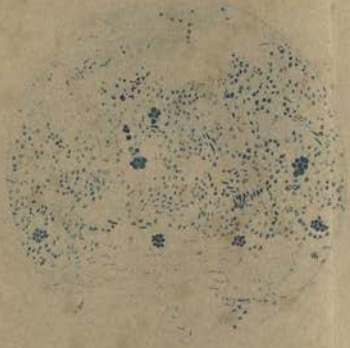


Fig 8 x30.

MYCETOMA. CONDITION OF THE VESSELS IN THE INITIAL STAGES &c.

Photo-etching.

Survey of India Offices, Calcutta. April 1891.

MAP RECORD AND ISSUE OFFICE.

Personnel.

Colonel W. H. Wilkins, S.C., officiating Assistant Surveyor-General, in charge.
Mr. A. E. Byrn, Head Assistant.
„ H. R. Vallis, Map Curator, and 13 clerks.
„ B. M. Wilson, Assistant Surveyor, 2nd grade, attached.

465. The general superintendence of this office has remained in the hands of Colonel W. H. Wilkins, S.C., throughout the year under report.

466. During the year, the number and value of maps issued were as follows :—

Maps issued.	Number.	Value.
		₹
General maps to Government officials	48,517	46,330
Ditto to India Office, London	7,088	10,774
Ditto to Agents	1,285	1,924
Ditto to private individuals	8,974	12,384
Total	65,864	71,412
Cadastral maps to Government officials	142,620	63,833
GRAND TOTAL	2,08 484	1,35,245

467. There has been a large increase in the number of maps issued and a corresponding increase in their value, as compared with last year's totals, which were 1,66,604 and 1,22,472, respectively.

468. During the year the actual cash sales amounted to ₹12,917, *viz.*, ₹12,384 realized from private individuals, and ₹533 from map sale agents showing an increase of ₹1,365 over the sales of the previous year. In the Revenue section, 754 applications were received for extracts from original records of the Revenue surveys and 4,177 certified copies of village plans, tracings and traverses were supplied at a cost of ₹8,901.

469. The details of work done are given in the following statement :—

Details.	Number.
Applications received for maps	5,445
Letters issued in reply	2,655
Cash and credit map sale bills	1,615
Invoices and receipts issued for published maps	2,154
Ditto ditto for cadastral maps	271
Ditto ditto for extracts from original records	315
Packets, parcels, and local despatches	3,412
Ditto received in the office	723
Packages despatched by rail and steamer	472
Ditto received by ditto	60
Maps, coloured, for sale and issue	29,727
Ditto for other departments	1,600

A list of the maps and charts published during the year is given at page 103.*

* Of the establishment in this office Mr. H. R. Vallis has discharged satisfactorily the arduous duties of map curator and salesman.

MATHEMATICAL INSTRUMENT OFFICE.

470. During the period under report the charge of this office has been held by Lieutenant-Colonel M. W. Rogers, R.E., Assistant Surveyor General, who also continued to hold the appointment of Patents Secretary.

Personnel.

Lieutenant-Colonel M. W. Rogers, R.E., Deputy Superintendent, 2nd grade, Assistant Surveyor-General in charge.

Workshop Branch.

Mr. T. Bolton, Mathematical Instrument Maker.
„ F. Marshall, Assistant Mathematical Instrument Maker.
197 artificers.

Store Branch.

Mr. W. Campagnac, Instrument storekeeper, up to January 1891.
„ M. C. Belletty, Ditto ditto, from January 1891.
Babu Woomesh Chunder Chowdhary, Material storekeeper.
1 packing sirkar and 2 packers.

Office Establishment.

Mr. C. O. Gray, Head Clerk, up to 31st December 1890.
„ W. Campagnac, Head Clerk, from 1st January 1891.
„ M. C. Belletty, 2nd Clerk, up to 31st December 1890.
„ W. R. Tulloch, Ditto, from 1st January 1891.
8 clerks.

471. The figures given in this report refer to the Financial year 1890-91, *i.e.*, from 1st April 1890 to 31st March 1891. During this period 63,196 serviceable instruments, valued at R2,59,909, were received into store, and 64,203 instruments, valued at R2,88,337, were issued; the number of serviceable instruments in store was therefore diminished by 1,007, whilst their value was diminished by R28,428.

472. The following tabular statement shows the principal sources from which the serviceable instruments were received:—

Sources of Receipt.	No.	Value.
		R
From England on indent	7,064	1,08,791
By purchase in the local market	21,062	32,550
Manufactured in workshop	19,069	26,581
Returned to store by public officers	887	23,345
From other manufacturing offices	3,250	89
„ repairable stock after repair	4,762	65,683
„ other services	7,102	2,870
TOTAL	63,196	2,59,909

473. The number and value of instruments obtained from England are considerably less than last year; but the value is much the same as that of the year 1888-89. It has been found necessary to increase the supply in the last indent submitted in order to meet to some extent the very large demands that are now being made for instruments. The purchases in the local market are a little in excess of last year in value, whilst the number of instruments manufactured in the workshop is smaller both in value and number, this decrease being balanced by a corresponding increase in the number and value of the repairs executed. Recourse to the local market for supplies is unavoidable owing to the impossibility of fore-seeing the demands of other departments for instruments and providing for them in the regular yearly indents on England. Sufficiently long notice is not generally given by Governments and departments of their probable requirements, and when their indents are sent in, the supplies are invariably required quickly.

474. The number of instruments taken from the repairable stock and rendered serviceable for issue is less both in number and value this year than last. This decrease is due to increased demands for current repairs to instruments sent in for that purpose, which, although the legitimate employment for the workshop, and one of the chief sources of the usefulness of the office, are of a kind which, whilst involving much care and expenditure of time, do not make a good show in the returns of the work of the office, as their money value is small. During the year the office received 3,668 repairable instruments (considerably less than the number received in either of the last two years) valued at R60,734. The total

issues from repairable stock were 4,785, valued at ₹43,801; these were repaired in the workshops at a cost of ₹21,882 and transferred at the enhanced value to the serviceable stock. The repairable stock has thus been diminished in number by 1,117 and increased in value by ₹16,933. This is satisfactory, as showing that there is no increasing accumulation of repairable instruments.

475. The conversion of old fashioned and obsolete theodolites and levels, alluded to in paragraph 494 of last year's report, has been continued, and in the financial year under report 16 theodolites and 25 levels were made into seviceable instruments, and all issued at a total value of ₹8,700, whilst in their original state they were useless for modern requirements. During the year 63,196 serviceable instruments have been received into store, making, with the 3,668 repairable instruments mentioned above, a total of 66,864 instruments.

476. During the year under report the resources of the Mathematical Instrument Office have been considerably strained by the requirements of the Meteorological Department, who have indented for the supply to almost the whole of India, of 5-inch rain gauges of an improved pattern furnished with spirit levels, testing gauges, and measuring glasses. The glasses have had to be obtained from England, but all the gauges have been made up in the workshops: their cost, however, does not enter into the accounts of this financial year.

477. Several large indents for cheap instruments have been received from the local Governments of the Central and North-Western Provinces, and these have been satisfactorily supplied; the Madras Revenue Survey has also indented largely on the office for measuring chains. A large amount of repairing work has been done for the Ordnance Department, chiefly in altering the service heliographs to agree with the new sealed pattern.

478. A considerable quantity of extra work has been thrown upon the office establishment by the new arrangement asked for by the Comptroller, India Treasuries, of demanding payments in cash for all charges under ₹50. This, and the general expansion of the work of the office, render advisable a small increase to the strength of the clerical establishment to prevent the work falling into arrears.

479. Table A (in the appendix) shows the amounts of debits against various offices and departments for instruments supplied and for work done. It also exhibits the credits for all instruments and materials returned to store. The value of the issues and repairs executed on book debit was ₹2,84,822, being ₹16,000 in excess of last year: this amount includes the value of instruments purchased with the extra-departmental grant of ₹36,000. The credits for instruments returned into store amounted to ₹84,666, which is slightly less than last year. The cash sales were ₹14,871 against ₹10,203 in last year.

480. During the previous year, 9,118 instruments valued at ₹29,505 were purchased in the local market. In the year under report the number was 20,013 and the value ₹32,551, the disproportion in the numbers and values being due to a larger number of items of very small value, such as pins for maps and chains, etc., being required. The actual number of instruments which have been manufactured in the workshop is about one-fourth less than last year, and their value is ₹4,000 less. This is due to a great extent to the larger number of repairs executed, and also to the fact that a large number of workshop manufactures were only partially completed at the date of closing the accounts, and therefore credit for them could not be taken. The figures for the last three years are given below:—

	Number.	Value. ₹
1888-89 . .	11,220	33,082
1889-90 . .	27,589	30,798
1890-91 . .	19,069	26,581

The class and value of these instruments will be found in Table C in the appendix.

481. The number of principal instruments repaired in the workshop is 2,473, which is almost the same as last year: the total number of instruments of all kinds repaired amounts to 3,565 compared with 3,104 in 1889-90.

482. The experience of the past year is the same as that of previous ones, and shows that the work of the Mathematical Instrument Office is steadily increasing, and that the demands for instruments and repairs become larger yearly, as is only to be expected from the large increase in survey, and other kinds of

work for which instruments are necessary. The Survey of India Department, although still the largest customer, took this year under one-fifth of the total instruments issued.

483. Stock taking has been carried on at intervals during the year whenever the services of one of the Mathematical Instrument Makers was available, but the ordinary business of the workshops now so fully employs their time that little progress has been made in it during the year under report. As it is desirable to complete the present stock-taking at an early date, arrangements will be made to depute an officer of the department specially for the duty.

484. The profit and loss account of the workshop will be found in the appendix; the result of the operations showing an apparent loss of R8,021 compared with an apparent loss of R1,213 on last year's work. This difference is due to there having been an unusually large amount of unfinished work in hand in the workshops on the 1st April when the balance was struck, which could not be brought to account. This will give an extra amount to be shown as gain in next year's accounts.*

II.—TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

485. The work of the office is divided into the following sections:—

(1) Correspondence, Accounts and Records.
(2) Computing.
(3) Type-printing.
(4) Drawing and compiling.
(5) Photozincography.
(6) Solar Photography.
(7) Miscellaneous.

486. The principal work is the final reduction and publication of the operations of the trigonometrical survey, and to the carrying out of this, each of the first five sections, mentioned above, contributes. The office has to deal with the principal chains of triangulation spread over the whole of India and the secondary triangulation executed in connection therewith; the astronomical observations for the determinations of azimuth and of latitude and electro-telegraphic determinations of differences of longitude; also with spirit-levelling operations and tidal observations.

Personnel.

Colonel G. Strahan, R.E., Deputy Surveyor-General, in charge Trigonometrical Branch.

Mr. W. H. Cole, M.A., Officiating Deputy Surveyor-General, from 27th October 1890 to 28th January 1891, and Deputy Superintendent, 2nd grade, in charge Computing Party, from 1st October 1890 to 26th October 1890, and 29th January to 1st April 1891.

Mr. J. Eccles, M.A., Deputy Superintendent, 4th grade, in charge Computing Party, from 27th October 1890 to 28th January 1891, and 2nd April to 30th September 1891.*

Lieutenant J. M. Burn, R.E., Assistant Superintendent, 2nd grade, from 10th May to 30th September 1891.

(1) *Correspondence, Accounts and Records.*

Mr. F. A. D'Rozario, Head Clerk, and 4 other writers.

(2) *Computing.*

Mr. H. W. Peychers, Surveyor, 2nd grade.
Mr. L. J. Pocock, Surveyor, 2nd grade.
Mr. H. G. Shaw, Assistant Surveyor, 3rd grade.
Babu Cally Mohan Ghose, Senior Computer.
Babu Kally Coomar Chatterjee, Computer.
Babu Amba Prasad, Computer, and 27 other permanent and temporary Computers, Recorder, and Account keeper and Librarian.

(3) *Type-printing.*

Mr. B. V. Hughes, Printer, 18 compositors and temporary hands.

(4) *Drawing and Compiling.*

Mr. C. H. McA'Fee, Surveyor, 3rd grade, 5 Draftsmen, 1 Sub-surveyor, and 11 Assistant and Apprentice Draftsmen.

(5) *Photozincography.*

Mr. T. S. Manuel, Assistant Zincographer, 2 Assistant Photographers, 2 Native draftsmen, and 1 Mapkeeper.

(6) *Solar Photography.*

Mr. C. F. Guthrie, Assistant Solar Photographer.

487. The reduction of the tidal observations is however made in the field party office; it is only in the compilation and publication of the results that this office is concerned. The calculations of observations for latitude, longitude, azimuth, etc., taken by various explorers are also performed in this office, and of late years a good deal of work has been done in this respect, not only in connection with explorations carried out by the Survey Department, but also by officers of other departments.

* Colonel Rogers reports most favourably on the zeal and ability with which Messrs. Bolton and Marshall have carried out the work during the past year, and states that the office is very fortunate in having the services of two such capable officers.

The correspondence and store branches under Messrs. Gray, Campagnac, and Belletty have worked well and satisfactorily, and these officers report well of all their subordinates.

488. The drawing and compiling section and the photozincographic section, although existing as auxiliaries to the computing section, for the publication of maps, charts, etc., required to illustrate the operations of the trigonometrical survey, have besides been engaged with other work; the former with the compilation and publication of exploration maps, charts of levels determined by railway and canal officers, and other miscellaneous maps; and the latter with a very considerable amount of work for the Forest Department, and for the Quarter Master General's Department.

489. The solar photography has been continued as usual; the work was started in 1877 at the request of the Industry, Science and Art Department, conveyed through the Secretary of State. At first the pictures were 4 inches in diameter, but later on they were increased to 8 and 12 inches in diameter. The 12-inch pictures are only taken when special features show themselves on the sun's surface. In addition to the ordinary daily routine of photographing the sun, some photographs of the planet Mercury during its transit across the solar disc on the morning of the 10th of May were obtained.

490 The work of the miscellaneous section is chiefly in looking after the depôt of instruments and stores appertaining to the trigonometrical branch of the survey, and of a special equipment for mobilisation which has now to be maintained on a large scale. It also includes the training of officers and explorers both of this and other departments, and certain scientific investigations which have to be made from time to time.

491. During the year under report, the office has been engaged in passing through the press volume XIV of the Account of the operations of the Great Trigonometrical Survey, containing the final reduction of the principal triangulation of the South-West Quadrilateral: this has been bound and issued. The volume dealing with electro-telegraphic differences of longitude, which will be the fifteenth of the series of professional volumes, has also been going through the press; and a beginning has been made with the printing of the letter press of the volume on tidal operations.

492. The synoptical volumes of the several chains of principal triangles, which are required by local officials and detail surveyors, have made rapid progress. Six of the Southern Trigon and one of the North-East Quadrilateral were occupying special attention. Of these, two have been printed and are now in the hands of the binder, another is about half printed, while the compilation of three others is nearly completed, and there remains only one which is still in a backward state. Some progress has also been made with the synoptical volumes of the South-West Quadrilateral, six in number. Hand-books for the Trigonometrical and Topographical branches have been printed, and two pamphlets of spirit-levelled heights, *viz.*, No. 5, Bombay Presidency, and No. 6, Madras Presidency, were printed, bound and issued: reprints of two exploration reports were also completed, of which one has been bound and issued, and the other is in the hands of the binder.

493. In addition to the regular work of the office, assistance has been afforded to the field parties as follows:—Two computers were lent for three weeks to the Astronomical parties, two computers were engaged for one month in preparing data for the officer who accompanied the Hazara Field Force, and two computers were employed for one month in the reduction of certain calculations appertaining to the triangulation in Baluchistan. The work done by the drawing and compiling section and by the photozincographic section will be found detailed in the appendix.

494. Photographs of the sun have been taken throughout the year on all days that the sun was visible, and the negatives sent to England to the Solar Physics Committee at South Kensington. The results of these photographs are included in the yearly volumes of the Greenwich observations.

495. Meteorological observations, including the record of the deep sunk thermometers, have continued to be taken as heretofore; the sunshine record has also been maintained. The preservation and issue of instruments have been supervised as usual, and the special equipment referred to above kept in an efficient state. One officer of the senior division and 32 candidates for the junior division have been examined, and one officer has received special instruction in the use of instruments appertaining to the scientific work of this branch. Further details of the work done will be found in the appendix.

496. The Surveyor-General inspected the Head-Quarter offices of the trigonometrical branch at Mussooree and Dehra in October 1891. The work in the various sections was found to be in efficient order and gave evidence of skilful administration. With the increased means placed at the disposal of the computing section for expanding the staff of computers, with a view to expediting the completion of the final reduction and publication of the trigonometrical records of past years, considerable progress had been made, but not so great as might have been expected. This was due to the small material assistance obtained from the new hands owing to the necessity of their being trained in the work required, and to their utilising the office as a stepping-stone for other appointments, from the fact of their being aware that the employment in the computing office is only of a temporary nature. Every endeavour is being made to push on the work as rapidly as is possible in the circumstances.*

III.—DRAWING OFFICE, SIMLA.

497. Under the orders of the Government of India the general supervision of this office is carried on during the recess season by the officer in charge of the Baluchistan party in addition to his other duties. During the field season the general superintendence of the office remains in the hands of the Deputy Quarter Master General, Intelligence Branch. Thus Colonel Woodthorpe, C.B., R.E., of the Quarter Master General's Department, held charge of the office from the commencement of the year under report until the 15th of March 1891, and again from the 10th of April, when Colonel Holdich proceeded on furlough, until the 22nd of June, when Captain Mackenzie, R.E., then in charge of the Baluchistan party, returned from the Miranzai expedition. As, however, Captain Mackenzie's services were shortly afterwards required at Quetta to superintend the recess work of No. 15 party, the services of Captain Wahab, R.E., who was on special duty in Simla in connection with the final mapping of the work done on the Black Mountain and Miranzai border, were utilized for superintending the work of the office until the close of the year under report.

Personnel.

Lieutenant-Colonel T. H. Holdich, R.E., Deputy Superintendent, 1st grade, in charge.
Mr. G. W. E. Atkinson, Surveyor, 1st grade.
„ W. J. Cornelius, „ 4th „
„ A. Kitchen, Assistant Surveyor, 1st grade.
„ F. E. Warde „ „ 2nd „
„ F. Rozario, Sub-Surveyor.
„ H. Sindon, Draftsman.
Munshi Jafir Khan, Draftsman.
Mr. W. Manly, Assistant Draftsman, and four other draftsmen.

498. The principal work of the season has been the preparation of the sheets of the North-West Frontier Series and of the South-West Asia Series, on the scale of 1 inch=8 miles. In addition to these, several miscellaneous maps have been prepared, illustrating the expeditions to the Zhob and Gomal valleys, to the Miranzai and Hazara borders, and certain explorations in Persia.

499. A new edition of the Turkestan map, on the scale of 32 miles to the inch, has also been under preparation. This has involved the entire re-drawing of the map, owing to the large number of corrections and additions rendered necessary by recent surveys. The two southern quarter sheets are completed in outline, and the two northern ones will shortly be commenced. The final map will be printed in two colours.

500. A new general map of Baluchistan on the 16-mile scale has been commenced and is nearly completed: owing to the urgency of the demand for this map, the present issue is only a preliminary one, and to save time in its preparation typing has been used instead of hand-printing. A final edition in two colours will be taken up when the $\frac{1}{4}$-inch survey of Baluchistan is completed.†

* Mr. Eccles reports very highly of his assistants, making special mention of Messrs. Peychers Mc A'Fee, Hughes, Manuel and Guthrie, who stand at the head of their respective sections; and of Messrs. Pocock and Shaw. He also bears testimony to the good work of the computers and draftsmen.

The Deputy Surveyor General reports very favourably on the services rendered by Mr. D'Rozario, the head clerk, and Babu Hira Singh, 2nd clerk of his office.

† The officer in charge reports as follows:—Of the assistants, Mr. Atkinson has borne much of the responsibility for the conduct of the office during the necessarily long absences of the Deputy Superintendent in charge. I cannot speak too highly of the ability and discretion with which his duties have been carried out.

Mr. Cornelius has maintained his high reputation as a careful and trustworthy compiler, as well as a rapid, skilful draftsman.

Mr. Kitchen has also done excellent work throughout the year both as a compiler and draftsman.

Mr. Rozario, with the draftsmen Messrs. Sindon and Manly, as well as Jafir Khan and Abdul Aziz are also well reported on.

LIST OF MAPS AND CHARTS PUBLISHED DURING THE YEAR 1890-91.

Title.	Scale.	Number of Sheets.	Remarks.
	In. M.		
Atlas of India.			
Sheet No. 15	1=4	1	With additions to 1890.
Sheet No. 47	1=4	1	With additions to railways and corrections to boundaries to 1891.
Quarter sheets Nos. 35 N. W., 48 S. E., and 131 S. W.	1=4	3	With additions to 1889.
Quarter sheets Nos. 13 N. W., 21 S. W., and 60 N. W.	1=4	3	With additions to 1890.
Quarter sheet No. 39 S. W.	1=4	1	With additions to 1891.
Quarter sheet No. 131 N. E.	1=4	1	
General Maps.			
Afghanistan	1=24	4	
Provincial Maps.			
Bombay Presidency	1=32	1	With additions and corrections to 1890.
Central Provinces, 1886	1=32	1	With additions to railways to July 1891.
Madras Presidency	1=32	1	With additions to railways to August 1890.
N.-W. Provinces and Oudh	1=32	1	With corrections to 31st March 1891.
Divisional Maps.			
Chittagong (Bengal)	1=8	1	
Presidency Division (Bengal)	1=8	1	With additions and corrections to railways and boundaries to February 1890.
District Maps.			
Bilaspur (Central Provinces)	1=2	5	One map in 2 and the other in 3 sheets.
Ghazipur (N.-W. P.)	1=2	2	
Garo Hills (Assam)	1=2	4	2nd edition.
Cachar (do.)	1=4	1	With additions and corrections to May 1890.
Darrang (do.)	1=4	1	With additions and corrections to July 1890.
Lakhimpur (do.)	1=4	1	With additions and corrections to boundaries and roads to May 1890.
Chittagong (Bengal)	1=4	2	With corrections to July 1890.
Darjeeling (do.)	1=4	1	Skeleton.
Dacca (do.)	1=4	1	With additions to boundaries and corrections to railway to March 1891.
Jalpaiguri and Cooch Behar (do.)	1=4	1	With additions and corrections to roads and boundaries up to April 1890.
Monghyr (do.)	1=4	1	With additions and corrections to roads and boundaries up to September 1889.
Rungpur (do.)	1=4	1	With additions and corrections to June 1889.
Singhboom (do.)	1=4	1	With additions and corrections to April 1891.
Standard Maps.			
Assam.			
Sheet No. 25	1=1	1	Preliminary edition.

Title.	Scale.	Number of Sheets.	Remarks.
STANDARD MAPS—*contd.*			
Bengal.	In. M.		
Sheets Nos. 3, 20, 22, 40, 41, 42, 96, 123, 156, 345, and 360.	1=1	11	
Bombay.			
Sheets Nos. 278 N. E., N. W., S. E. and S. W.	2=1	4	
Sheets Nos. 145, 146, 179, 233, 244, 277, 331, 352, 353, and 353 A.	1=1	10	
Sheet No. 198.	1=1	1	With additions and corrections to railways to May 1891.
Burma (Lower).			
Sheets Nos. 225 N. E./3, N. W./4, S. E./1, S. E./4	4=1	4	
Sheets Nos. 226 N. E./2 and N. E./4	4=1	2	
Sheets Nos. 7, 8, 9, 10, 24, 25, 26, 27, 28, 43, 44, 45, 46, 47, 180, 228, 229, 230, 235, 236, 276, 277, 282, 283, 322, 323, 324, 325, 327, and 328.	1=1	30	
Central India and Rajputana.			
Sheets Nos. 200, 254, 283, 284, 285, 312, 338, 339, 340, 341, 362, 368, 380, 389, 390, 391, 392, 393, 468, 477, and 479.	1=1	21	
Central Provinces.			
Sheets Nos. 12 S. E./3, S. E./4, 13 N. E./2, 19 N. E./1, N. E./3, N. E./4, S. E./2, S. E./3, S. E./4, S. E./1 and 2, S. W./1, S. W./2, S. W./3, N. W./4, 20 N. W./1, N. W./3, (N. E./1 and 19 S. E./3) (19 S. E./3 and 20 N. E./1) in one, (19 S. W./4 and 20 N. W./2) in one, (26 S. W./3 and S. W./4) in one, 26 N. W./3 and 26 S. W./1 and 2	4=1	22	
Sheet No. 19 N. E./2	4=1	1	2nd edition.
Sheets Nos. 32, 236, 237, 238, 239, 251, 252, 253, 254, 262, 263, 264, and 265.	1=1	13	
Madras.			
Sheets Nos. 1, 2, 3, 9, 10, 11, 12, 13, 14, 15, 23, 24, 25, 26, 27, 28, 29, 30, 31, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 68, 69, 70, 71, 72, 73, 74, 76, 77, 78, 79, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 135, 136, 137, 138, 139, 140, 171, and 203.	1=1	59	With corrections to roads and boundaries, 1890.
N-W. Provinces and Oudh.			
Sheets Nos. 12A, 26, 99, 113, 115, 145, 158, 159, 163, 167, 168, 172, 173, 174, 175, 176, 181, 188, 189, 190, 191, 192, 197, 199, 203, 204, 205, 206, 213, 214, and 215.	1=1	31	
Sheet No. 43.	1=1	1	With additions to railways to July 1891.
Sheets Nos. 53 N. W., S. W., and 185 S. E.	2=1	3	
Punjab.			
Sheets Nos. 231 N. E./9, S. E./2, S. E./3, S. E./5, S. E./6, S. E./9, 232 N. E./3, 246 S. W./1, S. W./4, S. W./7 and 247 N. W./1	6=1	11	
Sheets Nos. 246 N. E./1, N. E./2, N. E./3, N. E./4, N. W./4, 285 N. W./1, N. W./2, N. W./3, 310 N. E./1 and 2, 310 N. E./4	4=1	10	
Sheet No. 90.	1=1	1	2nd edition.
Sheets Nos. 144, 262, 280, and 325.	1=1	4	
North-Eastern Frontier Series.			
Sheet No. 15.	1=8	1	
Sheet No. 23 N. W.	1=4	1	4th edition.
Sheet No. 23 S. W.	1=4	1	3rd edition.

Title.	Scale.	Number of Sheets.	Remarks.
Standard Maps—*contd.*			
South Eastern Frontier Sereis.	In. M.		
Sheets Nos. 3A and 7	1=8	2	Preliminary editions.
Sheet No. 1 S. E.	1=4	1	4th edition.
Sheet No. 1 S. W.	1=4	1	
Sheet No. 2 N. E.	1=4	1	6th edition.
Sheet No. 2 S. E.	1=4	1	3rd edition.
Sheet No. 4 N. E.	1=4	1	2nd edition.
Sheet No. 4 N. W.	1=4	1	3rd edition.
Sheet No. 4 S. E.	1=4	1	2nd edition.
Sheet No. 4 S. W.	1=4	1	4th edition.
Sheet No. 5 N. E.	1=4	1	2nd edition.
Sheet No. 5 N. W.	1=4	1	4th edition.
Sheet No. 5 S. E.	1=4	1	2nd edition.
Sheet No. 5 S. W.	1=4	1	4th edition.
Sheet No. 6 N. W.	1=4	1	5th edition.
Plans of Cities and Cantonments.			
City of Calcutta	6=1	2	2nd edition.
City and environs of Lahore, with Civil Station and Cantonment of Mean Meer 1889-90	6=1	6	
Ferozepore Cantonment	6=1	1	
Rawalpindi Civil Station Cantonment, Town and environs, 1865-66	6=1	2	Partially corrected to 1890.
Town of Calcutta, showing boundaries of Wards	2=1	1	
Index Maps.			
Standard sheets of the North-Western Provinces and Oudh	1=48	1	
Standard sheets of Madras	1=48	2	
Index Chart of Triangulation of the Great Trigonometrical Survey of India	1=96	1	Corrected to 31st October 1890.
Statistical Maps.			
India, showing feeders to Railways, 1889-90	1=32	6	
Railway Map of India	1=32	6	Corrected to March 1891.
India, showing Railways	1=96	1	Corrected up to 31st March 1891.
India, illustrating the gauges of Railways	1=96	1	Corrected to 30th June 1890.
India, showing Telegraphs	1=96	1	Corrected to 31st March 1891.
Miscellaneous Maps.			
Kuttalam reserved forests, etc., Tenkasi taluk, Tinnevelly district, Madras	4=1	1	
Krishnapuram reserved forests, etc., Tenkasi taluk, Tinnevelly district, Madras	4=1	1	
Reserved forest, Block II, Shingalvariyar, Periyakulam taluk, Madura district, Madras	4=1	1	
Vasudevanallur reserved forests, Sankaranainarkoil taluk, Tinnevelly district, Madras	4=1	2	
Srivilliputur reserved forests, Srivilliputur taluk, Tinnevelly district, Madras	4=1	6	
Katankulam reserved lands, Srivilliputur taluk, Tinnevelly district, Madras	4=1	1	
Sirumalai reserved forests (Blocks I Serumalai, II Kachaikati), Dindigul and Madura taluks	4=1	2	
Reserved lands, Srivilliputur taluk, Tinnevelly district, Madras	4=1	2	
Ayyalur reserved forests, Dindigul taluk, Madura district, Madras	4=1	1	
Kadaiyanallur reserved forest and Reserved Lands Tenkasi taluk, Tinnevelly district, Madras	4=1	1	
Kapura Vallikutu and Akkamakardu reserved forests, Dindigul taluk, Madura district, Madras	4=1	1	
Tenkal reserved forest, Dindigul taluk, Madura district, Madras	4=1	1	
Parumalmulai reserved forest, Periyakulam taluk, Madura district, Madras	4=1	1	
Hazara Expedition, 1891	2=1	1	Preliminary issue.
Khanki valley (Miranzai border)	1=1	1	Do.
Ditto ditto	1=1	1	Do. (with additions.)
Part of Hazara and adjacent Independent Territory	1=2	1	
Preliminary Map of Chin hills	1=4	1	

Title.	Scale.	Number of Sheets.	Remarks.
Miscellaneous Maps—*contd.*	In. M.		
Reconnaissance of country traversed by the Anglo-Siamese Boundary Commission, 1889-90	1=4	2	
Preliminary Map of the Anglo-Siamese Boundary Commission, 1889-90	1=17	1	
Road Map of Punjab showing ferries, dák-bungalows, etc., 1879	1=16	2	With additions to railways to May 1891.
Skeleton Map of the Baluchistan and Sind Frontier	1=32	1	With additions to railways up to 1891.
Skeleton Map of the Afghanistan and Punjab Frontier	1=32	1	With additions to railways up to 1891.
Skeleton Map of Burma and Assam Frontier	1=32	1	With additions to railways up to 1891.
Triangulation Charts.			
Gujarat Survey, triangulation and traversing, quarter degree sheet XV, season 1885-86	1=2	1	
Nos. 56, 57 and 58 of Burma coast (between Kutubdia Light-house and Akyab) showing the positions of beacons, etc., 1889-90	1=2	3	
Mandalay series, season 1889-90 (Preliminary)	1=4	1	
Mandalay series, seasons 1889-90-91 (Preliminary)	1=4	1	
Gujarat Survey, triangulation and traversing, seasons 1873-85, quarter degree sheet H	1=4	1	
Gujarat Survey, triangulation and traversing, quarter degree sheet XV, season 1885-86	1=2	1	

APPENDIX.

EXTRACTS

FROM

REPORTS BY EXECUTIVE OFFICERS.

UPPER BURMA TRIANGULATION.

Statement of the out-turn of work executed by No. 24 Party during Season 1890-91.

Description of details.	
Number of principal stations newly fixed	5
„ „ „ triangles completed	8
Length of principal series in miles completed	44
„ „ approximate series in miles in advance	175
Area of principal triangulation, in square miles	900
Average triangular error, in seconds	0″·36
„ probable error of angles, in seconds	0″·15
Astronomical azimuths of verification	2
Number of principal stations selected in advance	13
„ „ platforms constructed for principal stations	18
„ „ principal stations placed under official protection and protected	13
„ „ principal stations, the elements of which have been computed	5
Area embraced by the triangulation to points exterior to principal triangulation, in square miles	320
Number of points fixed by intersection, but not visited	2
„ „ stations and points, the heights of which have been determined	7
„ „ miles of rays and pathways cleared	50
„ „ preliminary charts of triangulation	1
„ „ hill-tops cleared of forest or jungle	12

GUJARAT, BOMBAY PRESIDENCY.

Extract from a Report by MR. W. STOTESBURY, *Surveyor, 3rd grade, attached to No. 10 Party,—Season 1890-91.*

The eastern portion of sheet 183 came under survey this season, and embraced a small part of the petty State of Narukot (now under British administration) and a large tract of the Chota Udeypur State.

One long range of hills enters the sheet at the extreme north-east corner and abruptly ends at Kudvat; another range starts a little to the east of this place, and runs parallel to the former range and a few miles south of it. It may be said to begin in the remarkable block locally known as Rayapura. From Rayapura hill the range runs westwards, its northern face being very precipitous, while the southern face slopes gently for a few hundred feet, and then breaks up into a most intricate mass of low flat mounds of reddish clay with outcrops of granite and quartz, the whole cut up by a net work of ravines dense-

ly clothed with bamboo and thorny jungle. This mass of hills is about 4 miles wide, and some of the drainage breaking through the main ridge flows northwards through tremendous gorges, the precipices being on either side 600 to 700 feet in depth. The villagers cultivate a great part of the lower flat hills and slopes, felling and burning the forest and scattering the seed broadcast on the ashes when cool. There are a few isolated hills lying towards the south and east, some of them being very high and of a conical shape, forming conspicuous landmarks; of these the most prominent is called Masabar, lying 2½ miles north of the railway station of Bodeli, the terminus, for the present, of the Gaekwar's State Railway system on this side; another conical hill is Monju, 3 miles east of Jambughoda.

The only stronghold of any importance in this sheet is Páwagad. This remarkable hill forms a conspicuous landmark on the eastern horizon, as the traveller journeys by the Bombay, Baroda and Central India Railway after passing Baroda, from which place it is about 25 miles distant. It is an isolated block, the highest point in the country for miles around, and from its geological formation it is quite apparent that it belongs to the same group as the western ghâts, though separated from those mountains by about 50 miles of hill and plain, along which not a single feature is met with which bears any resemblance geologically to either Páwagad or the main chain of the ghâts. The height of Páwagad above mean sea-level is 2, 811 feet, and that of the plains at its base barely 400 feet.

A good road from Hálol, 5 miles westwards, leads to the old, historical, but now deserted city of Champáner, lying at the foot of Páwagad towards the north. From Champáner a well-made path ascends towards the fort along a gently sloping spur; the road winds up by easy gradients through the old Attock gate into a walled space, enclosing the ruins of an extensive city now lying desolate and overgrown with thick jungle. The old streets and houses are still distinctly traceable, but all is desolation and ruin; not a human being lives here; the only occupants of these old ruins now being large quantities of peafowl, jungle fowl, wild pigs, and a few deer. A little way up a deep tank with stone-faced sides is met with. This is called the 'Mendhi tank,' and along its banks lie carved pillars and sculptured blocks, with here and there an old temple or stately mansion more or less in ruin. Leaving this tank the road begins to rise more steeply, and after climbing up about a quarter of a mile, another walled enclosure is entered by a splendid arched gateway; the wall here is built up of immense stones, beautifully squared and dressed, and is 15 to 20 feet high, and the same in thickness, with another crenelated wall and platform on the top closely loopholed for musketry, with here and there strong bastions provided with gun embrasures. A ditch exists in places, but at present most of it has been filled up with the *debris* from the ruined wall itself and from the adjacent houses. From this gateway the road has been cleverly led through intricate gullies, flanked and enfiladed by high loopholed walls, and a little higher up, after passing through the remains of old gardens with ruined reservoirs for water, another enclosure is entered, containing a few buildings of modern date, one of which is used as a guard-house to accommodate the small guard of police quartered here to keep order among the thousands of pilgrims who visit this spot, in order to pay their devotions at the shrines on the summit of the hill. Another large double-storied building is now used as a *dharmsála* or rest-house. There are two tanks up here filled with water, called the Telia and Vasvel tanks, which are frightfully foul and used by the pilgrims for ablutions, cooking, washing clothes and by cattle indiscriminately. On passing out of this enclosure an old building, with three magnificent domes, is met with, and below are large reservoirs of water which are reached through holes in the floor: a little higher up the road bifurcates, one branch going off to the left along a flat spur to a temple dedicated to *Bhadar Káli Mátá*. This stands on the top of a flat knoll, surrounded on three sides by tremendous precipices 600 to 800 feet deep. At the point where the two paths meet the precipice from Bhadar Káli is joined on to the main block of the hill, and in the angle thus formed is a terrific chasm, 600 feet deep and only 150 yards wide. A hundred feet or so higher up from this point the road rises to the brink of a yawning gulf, 50 feet deep and 20 feet wide, across which a light wooden bridge is carried. In former days a draw bridge was dropped over this gulf from the gateway opposite, and this must have been a very strong obstacle in the way of an enemy, for there is no other way except through the gate; on the left being the escarped rock crowned by a loopholed wall 20 feet above the road, in front the yawning gulf commanded by the tower through which is carried the road, and on the right the steep slope of the hill which offers no foothold for hundreds of feet. On crossing the bridge and passing through the gateway the road narrows to about 6 feet and is cut through the solid rock, a parapet 6 to 8 feet only being left on the right, while the rock rises sheer on the left to a height of 50 feet. The path is carried upward in this way across the face of the precipice, the last gateway is entered and the citadel is reached. The top of the precipice is crowned by a strong wall with bastions and gun platforms at every commanding turn and point of vantage, and thus the whole of the lower fortifications and the road up are entirely enfiladed from the citadel. The interior of the citadel consists of a flat plateau and is some 2,000 feet above the level of the base of the hill. From the centre of this table-land another hump of rock rises to a height of 250 feet with precipitous sides; its summit is crowned by the temple of Káli Mátá, and near it lies the shrine of a Mahommedan saint, Sadan Pir, both being located under the same roof and separated from each other by only a thin wall. The path after leaving the gateway runs south-east at the base of the central bluff close by the Chhasia tank, generally dry, and past several beautifully sculptured old Jain temples rapidly falling into ruin.

On reaching the southern foot of the crag the path trends northwards and skirts another tank, which, from the whitish color of the water in it, is called the Dudhia tank. On its northern bank there is a fine Jain temple, with fluted dome dedicated to Bhadrinath; from this temple a flight of stone steps carries the path up the face of the precipice, and so to the summit of the central ridge or hump, the keep of the upper plateau and fort. Near the summit is the platform enclosing a station of the Great Trigonometrical Survey, and a few more stone steps lead up hence to the gateway into the enclosure, in which are the two shrines previously alluded to. A glorious view of the surrounding country is to be had from here: to the east, in the hazy distance, are visible the high peaks and ranges of the Vindhya mountains which may be said to end here; southwards and westwards stretch the black cotton-soil plains of Gujarat, dotted with hundreds of villages, and here and there sparkle the many small tanks met with all over this part of the country. About eight miles to the south-west, is seen the large sheet of water, some 4 square miles in extent of the Suriya lake, built by the Gaekwar's Government at a cost of several lakhs of rupees for the water-supply project of the town of Baroda.

The old city of Champáner which lies at the foot of Páwagad towards the north-east, is now a heap of ruins, containing a few shops, a temple or two, and a police station, with a population of hardly a hundred souls. Its magnificent ruins can be traced for miles around to the east and west, and cover an area of fully 8 square miles; several fine temples still standing testify to the grandeur and magnificence of this once populous and flourishing city. The grandest of these is the Jama Masjid, situated just outside the walls of the city towards the north-east angle, which must have been a beautiful building in its day. It is built of stone; the domes are most cleverly raised on square bases and both the interior and exterior of the domes and of the whole building are faced with well-dressed stone slabs of very large size. The minarets rise gracefully at either end, and are elaborately ornamented with sculpture. Several other smaller masjids are met with lying desolate in the midst of dense thorn jungle; some of them rapidly falling into decay; among these are the Wandra, the Kamina, and the Nagina Masjids lying north of the city, and the Panch Mahuda on the west. A mile further west is a single minaret called the "Eval Minar," and within the old city walls opposite the Attock gate of the Páwagad fort is a large masjid now used as a traveller's bungalow. On the top of the hill is another five-domed building, called Makái Kothar, said to have been used as a granary in the old days; this building is also used as a rest-house for Europeans visiting the hill. The Jama Masjid has just been repaired by the British Government.

BELUCHISTAN.

Extract from a report by MR. E. GRAHAM, *Assistant Surveyor, 1st grade, on his Survey operations in Makran, Season 1890-91.*

The detachment assembled at Karachi on the 23rd of October, and after arranging for transport supplies, left for Bela on the 7th of November. The programme was to continue the Makran series from the most western base laid down last year west of Las Bela, following as nearly as possible the parallel of 26°, so as to connect with the triangulation executed in South-West Baluchistan the previous season, and having effected this junction, to lay down as many points as possible over the remaining untriangulated area.

In starting work, I decided to lay out a degree in longitude at a time, and then complete the observations in this degree. I was just completing those of the first degree, when Sir Robert Sandeman's camp arrived, and I applied to the Political Agent, South-West Baluchistan, who was with Sir Roberts' camp at the time, for an escort, to enable me to carry on the work in the next degree. This was refused on political grounds, and I therefore determined to march to Kej and work down towards Pasni and Gwádar.

On arrival at Kej I started the triangulation in the direction of Pasni. I found that the country offered every facility for a very perfect series of quadrilaterals. It would follow the Kolwah and Kej valleys, which are practically one and the same, there being no *kotal* between the two worthy of that name. On either side of the valley was a range of hills running parallel to it, the distance between the two ranges varying between 18 and 20 miles. The weather was very hazy, the heat unbearable, and the haze made me quite despair of carrying the series down to Pasni that season. When I had got half through, I was warned by the Sirdar of Pidark that the country was in an unsettled state, and so I decided to march for Gwádar, working along the coast as I proceeded.

The total out-turn of triangulation for the season is 7,900 square miles. The results obtained from the series are very satisfactory; the work about Kej and Pasni is also good, though all the observations are not complete.

The country over which the series passed may be described as a succession of hills and valleys. First comes the Hada range overlooking the Bela plain on its east, and the Arrah and Jhao plains on its west. Then, west of the Jhao plain is another mass of sandstone ridges overlooking the Kolwah valley, and west of the Kolwah valley is a very high range known as the Kholwah-band.

The Hada range is a mass of sandstone and hard clay, resembling very much the hills about Bostan Railway station near Quetta, and consists of two ridges, the eastern one of which passes along, with a strike almost due north and south, down to the coast. The western ridge is very precipitous, and its strike is slightly east of north. This range

appears to be the eastern limit of a system of hills which form a complete semicircle, the centre of which lies about the Mashkel Hamun.

The Arrah plain is a perfectly barren piece of ground, interrupted by several large streams and ravines, with a few low sandstone ridges lying between it and the Jhao valley. The plain is used only by shepherds, who graze their cattle over it. There is plenty of water in the Arrah river.

The Jhao valley is long, fertile, and fairly well wooded. The Nali river which takes its rise about 20 miles south of Kalat flows through it. The valley lies north and south, its greatest length being about 45 miles and breadth 20 miles, and very large portion of it, in fact all the available ground, is under cultivation. Several hamlets are scattered about on both sides of the river, and the population of the valley is probably 4,000 The water-supply is from wells. Jhao is a settlement belonging to the Bizanjo section of the Brahuis. The Bizanjos are a very powerful and numerous section; the total number of the section is over 10,000 men.

Kolwah is an enclosed valley resembling the dry bed of a lake. There are several large villages and forts scattered about the valley, the principal of which are Hor, Sher, and Nag belonging to the Naosherwani Chief, Biloch Khan; Chambor, Bazdad, and Awara belonging to the Bizanjos; and Gushanak, Mattar, and Bedi belonging to the Mirivaris, a small section of Brahuis, numbering about 1,000 fighting men in all. The Kolwah valley is hemmed in on the north and south by two ranges of hills, and to the east and west are two very easy *kotals*, one connecting it with the Jhao, and the other with the Kej valley. To the north, between the villages of Awara and Bedi, the Durashi and Mashkai streams run through the valley, in a south-easterly direction, into the Nali river. The latter, after its junction with the Mashkai and Arrah streams, and after passing through a very narrow defile through the Goran hills (also called Taloband), is known as the Hingoli. This defile is known as Hingoli Dhat, and is impracticable for man or beast. The drainage from the eastern, western and southern portions of the Kolwah valley collects in the valley itself, and after heavy rain two lakes are formed, one of which is called Kap (meaning a salt swamp), and is about 20 miles in circumference, lying between the forts of Chambor and Hor, the other lake is about one-fifth the size of that abovementioned, and is known as Marav, which means a sweet water lake. Cultivation is carried on very largely in Kolwah; the soil is good, and with peace and order restored in the valley, the area under cultivation could be increased threefold.

The different tribes met with are Bizanjos, Mirivaris, Naosherwanis, and Kaodais. The first two are Brahuis and the others Baluchis; with the exception of the Naosherwanis, they are all peaceable and well disposed people, but the Naosherwanis are a very dissatisfied and untrustworthy lot. They are continually quarrelling with, and looting their neighbours, and are the dread of the whole of South-West Baluchistan.

Report by AHMAD ALI KHAN, *Sub-Surveyor, on his exploration of Sarhad (Persian Baluchistan) and Sistan (Eastern Persia) during season 1890-91, with a brief description of the country.*

I was directed by the officer in charge of the Baluchistan Survey to join the Agent to the Governor-General, Baluchistan, at Panjgur, who would instruct me as to the scope and extent of my exploration in Sarhad of Persian Baluchistan, and Sistan of Persia. I accordingly left Quetta on the 27th December 1890, and reached Panjgur 20th January 1891. Here I reported my arrival to Sir Robert Sandeman, who then made arrangements for me to proceed northwards.

On the 27th January a large Durbar was held for the Baluch Chiefs, and the Agent to the Governor-General was gracious enough to present me with a *khilat* in recognition of my previous work. On the following day I left Panjgur for Jalk *viâ* Kuhak, Isfandak, and Kallagan. From Jalk I started plane-tabling *en route* to Ladis, leaving the road now and then, and reached the latter place on the 24th February. Continuing my work northwards *viâ* Duzdap and Malik Siah Koh, I reached Sekoha on the 9th March. Here different arrangements had to be made, as I was not permitted to proceed to Nasirabad until permission was obtained from the Sarhang in command there. After a delay of nine days the welcome permission arrived.

On the 19th March I started, leaving my camp equipment behind and most of my escort. My following consisted of four mounted men and one *khalási*. The latter was utilised for pacing to check my timing on horseback, for I could take nothing in the shape of surveying instruments. Thus the position of Nasirabad and also of the eleven villages north of Sekoha should be considered approximate, as I had even to judge my direction to the best of my ability. After a stay of two days at Nasirabad, during which time I collected as much information as possible, I retraced my steps to Sekoha. Here I was again detained, as the inhabitants refused to sell me supplies, and it was only after much difficulty and persuasion that I obtained what was wanted at three times the local rates. From Sekoha I struck across country, taking the direction of the Taráku fort. Then, marching and working along the northern edge of the Hamun-i-Zirreh, I traversed its whole length and caught up the Nasirabad-Khárán route at the Orak springs. This route I now adhered to, and crossing the Amir Chah Kotal I made my way to Khárán *viâ* Panihám and Kondi. On the 14th May I reached Khárán, after having completed the 4-inch recon-

naissance of nearly 22,000 square miles of ground, and compiling route reports, not only from authentic information, but from personal observations also, of nearly 1,000 miles in length.

I should not omit to note that the whole of the reconnaissance, with the exception of the bit north of Sekoha, is based on trigonometrically fixed points furnished by the Afghan Boundary Commission, and also by Mr. G. P. Tate, Assistant Surveyor.

Sarhad comprises an area, roughly speaking, of about 11,000 square miles, and is confined between the parallels of 28° and 30° North Latitude, and 60° 45′ to about 62° 45′ East Longitude. The average height of ground level is about 4,500 feet. Continuous chains of hills traverse the country in a N. W. and S. E. direction, with broad intervening valleys along which pass the principal routes. The whole of Sarhad is considered Persian Baluchistan, and is supposed to be directly under the authority of the Governor of Kirmán, the present incumbent being Mirza Abdul Majid Khan, Farman Farma-i-Daulat. The authority, however, is almost nominal, for the inhabitants are a wild, turbulent race, and lead a very independent life. Not a *tahsil* or *thana* exists throughout the land, and no man who has any vested powers from Persia resides in Sarhad.

The most important place is Ladis, which comprises seven villages and a fort, situated close together, the population of which at present may be estimated at about 1,200. The fort is built on the right bank of the Ladis river and is 150 feet above the bed: its dimensions are approximately 600 feet square, and it is surrounded by a wall 20 feet high, with bastions at the corners. Altogether the fort is a very inferior one. In the interior there are 100 houses, which are inhabited during the summer months only by Rekis. Surrounding Ladis there are about 1,400 acres of cultivated land, the cereals grown being wheat and barley. The produce suffices simply for home consumption, and *ghi* is the only commodity exported. There is a perennial flow of water in the Ladis river and numerous springs, all of which are utilised to a great extent in irrigating the land. I was informed that the Governor of Kirmán intends shortly to build a fort at Ladis capable of accommodating 200 sowars, and has levied a tax on the inhabitants of one-sixth of the annual crop: this they have refused to pay, and have signified their intention of bodily migrating to Khárán if any attempt is made to enforce the tax. The total number of houses in Ladis is about 300. South and west of the volcanic mountain of Koh-i-Taftán there are numerous villages.

The cultivated land, both in Persian and Afghan Sistan, amounts to about 3,000 square miles, which large tract is irrigated chiefly by canals fed from the Helmand river. The soil is so fertile that the sowing of one season is sufficient to yield crops for the following two. Afghan Sistan possesses 70 villages: the Persian side 100. During the period of Timur's (Tamarlane's) invasion of the country, nearly 800 years ago, numerous strong forts were erected between Puzai Margo and the Helmand. These are still in a state of preservation, though never looked after or occupied. The name of the tract where these forts stand is Sar-u-tar, signifying deserted.

The great Hamun or Gaud-i-Zirreh is 85 miles long, about 30 miles broad, and has an average depth of 10 feet. In dry seasons, however, this is greatly reduced and *khafilas* easily cross. The water is utterly undrinkable, and animals even refuse to touch it. On the north, running the whole length of the Hamun, is a bank 40 feet high, forming the southern limit of the Dasht-i-Taráku. Herds of wild asses abound in the neighbourhood. The soil all round the Hamun is covered with a white efflorescence. The tamarisk is found in small clumps scattered about, and grazing for camels is very plentiful. When the Helmand river receives an unusual supply of water, either from the melting of the snows or an abnormal rainfall, the reservoirs which receive its waters, such as the Hamun-i-Sistan and the Hamun i-Sowaran, overflow; the volume of water takes a southerly course, and after inundating a tract of land 130 miles long, with an average width of 30 miles, empties itself into the Hamun or Gaud-i-Zirreh.

The place second in importance to Nasirabad in Sistan is Sekoha; it is 23 miles south of it. A rectangular wall, 1,200 feet × 900 feet and 20 feet high, encloses all the buildings. In the centre, on a knoll 200 feet high, a small pucka fort is built, which contains a company of infantry. The population of Sekoha is equal to that of Nasirabad. The present Sirdar is Pasánd Khan, who has friendly feelings towards the British. The water-supply from a canal is very good. Supplies, such as wheat, barley, *bhusa*, etc., can be procured in large quantities. No pasturage for animals exists nearer than 15 miles from the town, and wood is almost as scarce. The camping ground is on the west side of Sekoha. Every European travelling northwards is stopped here until permission is received from Brijand for a safe conduct. In the case of Native foreigners travelling in the same direction, permission or otherwise from Nasirabad is sufficient. In ancient times Sekoha was the capital or chief town of Sistan, but on account of the constant depredations of the tribes from Sarhad, Nasirabad was brought into existence and gradually took the first place.

There are other forts of minor importance about 30 miles south, such as Hauzdár, Machi, Kundar, Ramród, etc. There are traces still visible that the whole tract of ground where these forts stand, was once well populated, and that in fact it was in a flourishing condition. Twenty-five miles east of Ramród, on a hillock 200 feet above ground level, there stands a very strongly fortified post, called Taráku, which, although unoccupied, is in perfect order. Inside of the surrounding wall there are very good specimens of architecture, the walls of which are all ornamented with paintings. The tradition is that 1,500

years ago this was the birthplace of Rustam Pailwán, the Persian Palladin, whose life is shrouded with romance and mystery. The fort is called Taráku, derived from Tarkiden, which signifies 'bursting,' as the mother of Rustam Pailwán had to undergo the operation called the Cæsarean section before she could give birth to her son. Taráku was then the most important town in Sistan.

There are two canals worthy of note. The first and longest is that called Nair-i-Sistan; it is 60 miles long, with an average width of 30 feet and depth of 10 feet. The main branch with its numerous outlets irrigates about 3,000 square miles of land. The second largest is called the Nair-i-Taráku, which passes the fort of Taráku half a mile to the south. It is about 50 miles in length and of variable breadth, and used, in times gone by, to irrigate about 1,000 square miles. At present it is not worked on account of the deserted state of the land. Both these canals are fed from the Helmand. In 1885, when the river overflowed, a large volume of water found its way into the Nair-i-Taráku, burst its banks and inundated the country westwards for miles.

About 22 miles due west of Nasirabad there is a flat hill called Koh-i-Khwaja. It is about 500 feet above ground level. A fort stands at the southern base. The remains of numerous houses are still visible, all more or less fortified, on the summit, and huge caves exist on the slopes. The area of the level ground on top would be about one square mile.

The men of Sistan are on the whole a pacific lot. Very few are to be seen armed, and then only with the antique matchlock.

Koh-i-Taftán is the most remarkable mountain in Sarhad. There are two peaks a mile apart on the crest lying north-west and south-east, which are about equally high. To the north-west peak an approximate height was obtained giving a result of 14,000 feet above sea-level. The south-east peak is volcanic; there are two distinct craters on it which, when witnessed from any distance, appear to be only one. The whole of the higher crest of this range is covered with snow throughout the year, and the volcano lies dormant during the winter months. The streams which take their source from the range have a continual supply of good drinkable water. Skirting the bases on both sides there are numerous villages possessing large orchards and vineyards. Pomegranates, apples, apricots and peaches are to be had in abundance, the first two especially being of excellent quality.

The physical features of Sarhad present no difficulty whatever to any enterprise that may be undertaken either in the construction of railways or roads. The valleys are all broad and fairly level, with an average height of about 4,500 feet above sea-level. The *kotals* or saddles over which the principal routes pass are all accessible even in their present state for laden animals and mountain batteries. The main ranges which take a north-westerly direction are all more or less continuous and skirted on both sides by rather rugged ground, sparsely covered over with stunted trees. There is, however, an abundance of pasturage in the valleys during the summer months. Sarhad is actually the hot-weather resort for the inhabitants of Sistan and the Helmand valley.

The soil is unfit for cultivation, even when irrigated, as there is an admixture of sand combined with stones: this is particularly the case in the valleys. The ranges are all of sandstone formation totally devoid of any vegetation. The majority of the watercourses have always a good supply of running water. The best springs are to be found at the base of the Koh-i-Taftán range.

As a very small proportion of the inhabitants are agriculturists, large quantities of wheat and barley are imported into the country from Sistan, which are bartered for ghi in the proportion of 7 maunds of wheat for one of *ghi*. The maund is equivalent to about 6½ seers Indian weight. With the exception of woollen *numdahs* nothing whatever is manufactured in the country, and all muzzle-loading guns, matchlocks and swords are imported from parts of Persia.

Sistan comprises an area of about 20,000 square miles. The Helmand river from Chahar Burjak takes a northerly course and flows through it, dividing it into two parts. From the east or right bank of the Helmand up to the great Dasht-i-Margo plain is Afghan Sistan; that on the left bank up to the lofty Palang Koh range is Persian Sistan. From north to south it extends from Lash Juwain down to the Lar Koh and Kach Koh hills.

The tri-junction boundary pillar of Persia, Afghanistan, and Baluchistan stands on the summit of Malik Siah Koh, and was erected by General Sir F. Goldschmid in 1872, south of Sistan; the pillar was found destroyed. A fresh pile of stones 8 feet high and 5 feet broad at the base was erected. Afghan Sistan, comprising Chakansur, Kali-Kang, Kalifat, etc., is subject to the authority of the Governor of Farrah: Western Sistan, comprising the important town of Nasirabad, and others of less importance, such as Sekoha, Dowlatabad, etc., is under the direct authority of the Governor of Birjand in Persia.

The town of Nasirabad is about half a mile long and a quarter broad. Before the Husseinabad fort came into existence, twenty years ago, the fort of Nasirabad was attacked and destroyed by the Baluchis under Sher Muhammad Khan, Sanjaram of the Helmand valley. The population of the town now is about 4,000, inhabiting 700 houses. The majority of the people are agriculturists. Woollen *numdahs* and carpets of inferior quality are manufactured. There are no bazaars or shops, and even the ubiquitous *bania* does not find an abode here. The reason of this is that the religious teaching of the Persians, who are *Shiahs*, precludes them from buying or receiving anything for consumption from a Hindu. *Atta, dhal, ghi*, fowls, eggs, sheep, and *bhusa* are to be obtained

in large quantities and very cheap. The imports are sugar, tea, indigo, and ingredients for cooking. The following are the rates obtainable :—

Wheat	6 maunds	for 1	karan.
Barley	10 maunds	„ 1	„
Ghi	1 maund	„ 7	„
Fowls	4 or 5	„ 1	„
Eggs	120	„ 1	„
Wood	1 maund	„ 2	„

The maund is equivalent to about 7 seers Indian weight. The karan equals 6¼ annas.

The exports are sheep's wool, goats' hair, and *ghi*. One-third of all the produce of the country is taken as revenue by Government. The Persian Sistanis are not migratory, while the Baluchi Sistanis on the other hand are never stationary. The latter being a pastoral race move about with their cattle wherever grazing grounds are most favourable. The animals are taxed at the rate of 1 karan for every bullock or cow, and 1 karan per annum for every seven heads of sheep or goats. The whole amount of taxes thus imposed amounted during the past year to 40,000 karans.

HIMALAYAS, PUNJAB.

BARA BANGAHAL, KANGRA DISTRICT.

Extract from the Narrative Report of MAJOR ST. G. C. GORE, R.E., *in charge of No. 18 Party (Himalaya), Season 1890-91.*

The survey of Bara Bangahal had been added to the programme by request of the local authorities. Fortunately it had been triangulated previously, so I was enabled to have the topography taken in hand. For this purpose Mr. Senior, who had been recessing in Kulu after his triangulation in Láhul during the previous summer, was sent into Bara Bangahal as soon as the weather permitted.

This remote and outlying portion of the Kángra District comprises the head waters of the Ravi river, and embraces an area of about 250 square miles. It is without doubt one of the most isolated and inaccessible portions of the Himalayas. Cut off on the north-east and south from the neighbouring districts of Láhul, Kulu, and Kángra by watersheds ranging in height from 16,000 to 19,000 feet, it is even more inaccessible from the west, along the Rávi, as the great spurs from the watersheds drop precipitously into the river. There is a track leading up to the river from Chamba, but it is only just practicable for human beings. The best road into it is over the Thamsir Pass, 15,546 feet above sea-level, leading from Palampur in Kángra. There is but one village, Bangahal, situated low down near the Rávi, at a height of 8,340 feet, and there is a small amount of cultivated land near it. There are eleven Government Forests in Bara Bangahal, but their boundaries are undemarcated, and from the nature of the country it is difficult to see in what way the timber can be utilized.

The physical conformation of the country consists of lofty spurs converging from the surrounding watershed towards the west centre of the district to about the point where the village is situated, the heads of the intermediate valleys being filled with glaciers. The lower limit of the glaciers may be taken at approximately 13,000 feet.

The principal passes are as follows :—

(i) Those leading into Láhul—		
Over the Sha Glacier to Gushal 16,829 feet, by the Laluni Nal to Muling	17,841	feet.
(ii) Leading to Kulu—		
The Tainta Pass to Beas Kund	16,391	„
The Thanaod Pass, height not ascertained.		
The Kaliheyni Pass	15,284	„
(iii) Leading to Kangra—		
The Makori Pass	14,774	„
The Barla Pass	15,500	„
The Thamsir Pass	15,546	„
(iv) Leading to Chamba—		
The Nikora Pass	15,694	„

The greater number of the inhabitants are nomads, crossing over in the winter into Kángra with their flocks, and returning in summer when the passes are open. A few people stop in the village through the winter, cut off of course entirely from the outside world.

Mr. Senior finding that the Thamsir Pass was not likely to be opened till late in May, determined on crossing over by the Surai Pass into Chamba, and thence up the Rávi valley. After one or two ineffectual attempts he succeeded in crossing the pass on the 22nd April, though he had to leave a good deal of his baggage in the snow, sending back for it subsequently. He prosecuted his work under great difficulties owing to bad weather, but succeeded in completing the plane tabling of the district on the 1-inch scale early in July, having mapped an area of 254 square miles.

The heavy snowfall of the previous winter which in many way was so detrimental to the prosecution of the work proved in one way to be a considerable aid, for Mr. Senior was enabled to make his way up otherwise impassable *nalas* over the snow, with which they were so thickly filled.

LATITUDE OPERATIONS.

Extract from the Narrative Report of LIEUTENANT G. P. LENOX-CONYNGHAM, R.E., *in charge Nos. 22 and 23 Parties (Astronomical), Season 1890-91.*

The new zenith telescope having been received from Messrs. Troughton and Simms, I was ordered to undertake the determination of latitudes with it by Talcott's method.

I tested the levels which were mounted on it and found that the larger one, on which the accuracy of the method in great measure depends, was very sluggish and not as sensitive as it should be. I therefore tested six levels by Holmes which were in store: these I found to be very much better, being sensitive and at the same time settling very rapidly. I selected the two I considered best, and had one of them mounted on the instrument, keeping the other as a spare level.

I also took observations to determine the value of a revolution of the micrometer head, and the intervals between the vertical wires in the telescope.

The stations at which latitudes were to be observed are on the Madras meridional series between Dhulipalla, where observations were taken in 1888-89, and Saint Thomas' Mount, Madras, and are seven in number, *viz.*:—

1. Saint Thomas' Mount, Azimuth Station	13°	0′
2. Madras Observatory	13	4
3. Gudali Hill Station	14	1
4. Kistama Hill Station, Azimuth Station	14	27
5. Darutippa Station	15	1
6. Ongole Hill Station	15	30
7. Danapa Hill Station, Azimuth Station	15	56

all being approximately on the meridian of 80° East longitude.

I had received instructions only to take the latitude of Madras Observatory if it seemed to be required, and that the advice of the Government Astronomer should be taken on the subject. Mr. Pogson was in favour of having it taken, as there was apparently some doubt about its correctness, values differing by 1″ having been used by former astronomers. With the approval of the Deputy Surveyor General it was decided to adopt Madras Observatory as one of my stations.

Observations were commenced at Saint Thomas' Mount on 19th December. Though I had put off the commencement of work till so late in the hopes of fine weather, still I was a good deal interrupted by clouds which came up in greater or less quantity almost every night, though the days were perfectly fine. I completed my observations there on the 30th, having observed 15 pairs four times each, 15 three times, 8 twice, and 2 once. I moved to Madras the next day, and there I also had cloudy weather, so that I did not complete the observations till the 11th of January. Mr. Pogson was most kind in every way, taking great interest in the work and affording me every facility for carrying it on.

I erected my instrument on a small granite pillar which had been built some time before on the meridian of the longitude station used by this department: the centre of my instrument was 41 feet 7½ inches north of the longitude station. I had had a floor prepared, so as to minimise all chances of disturbing the instrument when moving about in the observatory. It was not ready for Saint Thomas' Mount observations, and unfortunately it would not fit round this pillar, as it had been made for my tripod. I attribute the larger probable error of the first two stations to the want of this floor. At the Madras observatory I observed 21 pairs four times each, 15 three times, 3 twice, and 1 once.

I left Madras on the evening of the 14th and reached Gudali on the 16th. The station is at the top of a hill about 300 feet above the surrounding country, and is entirely covered with cactus and scrub jungle. The Great Trigonometrical station is situated at the north-west quarter of the hill. Some deviation of the plumb-line towards the south may perhaps be discovered, but it cannot be very great. No more central position could have been made use of, as the form of the hill would have shut out all view to the north. I had a meridian mark built in the plain to the north, about ¾ mile off, so as to be able to correct my azimuth without waiting for transit of a circumpolar star.

I set up the instrument and began work the night I arrived. Clouds prevented work on two nights, otherwise all went well. I completed my work on the 25th, having observed 37 pairs four times and 8 three times.

I had written from Madras to the Deputy Surveyor General to propose a method of procedure different from what had been laid down for my guidance. Up to this I had used two programmes of 20 pairs each, each of which was observed on four nights. It seemed to me that I should obtain better results by using three programmes of 20 pairs each, observing each twice, as I should then have 60 values from independent stars whence to deduce my latitude, instead of 40. I heard now that I might employ this method at three of my seven stations, retaining that originally decided on for the other four.

As a matter of fact I only employed this method once (at Darutippa station), owing to the impossibility of obtaining a sufficient number of pairs of stars, but a scrutiny of the probable errors of the different latitudes will show that I was correct in my idea that it is of more importance to increase the number of pairs observed, rather than the number of observations of each pair. With so light an instrument as the zenith telescope it seemed improbable that changes of instrumental position would produce much effect, and the results bear this out.

Leaving Gudali on the 27th I reached Kistama on the 30th, and camped at the bottom of the hill that day. The hill is about 350 feet high, covered with dense jungle, through which a road had been cut by the sub-surveyor. The platform of the Great Trigonometrical station was rather out of repair, but this had also been made right. It would be advantageous if in future all platforms were made square with two of their sides lying approximately in the meridian: if this is not the case, it is difficult to erect the observatory tent. The station here is well placed, so that no deviation of the plumb-line is to be expected.

I noticed a very great unsteadiness in the instrument at this station. The vertical axis did not retain its verticality however carefully adjusted, for more than a short time. I tried every expedient I could think of to correct this, tightened up all screws both of stand and instrument, tested the counterpoising, and finding it not good, improved it by means of a piece of lead tied on. Still the unsteadiness was apparent, not always, but about every second night. On examining the notes I had made on the subject, I discovered that the unsteadiness was always apparent during the early programmes, 7 P.M. to midnight, and not during the late programmes, midnight to 5 A.M. This pointed to expansion and contraction as the cause, for the temperature falls rapidly from sunset to midnight, but is fairly steady after that. Further experience has placed it beyond a doubt that this is really the cause, and it is only necessary for the observer to watch his instrument carefully and keep on adjusting, so that the amount of dislevelment may never be so great as appreciably to affect his observations. I would suggest that before being used again, the instrument should be provided with a better transit-axis level, the one at present in use being a particularly bad one.

I completed my work on the 7th of February, having observed 35 pairs four times each, 8 three times and 2 twice, and moved down the hill the next day. My march to Darutippa took me through Nellore. I had heard that there might be difficulty in crossing the Pennair: however, the anicut proved to be quite clear of water and in good repair.

I heard from the sub-surveyor that he would not be able to have a pillar ready for me till the 20th, owing to difficulties in procuring bricks lime, etc., so I halted at Nellore for three days, and reached Darutippa on the 18th, where I found that he had selected a point on the prime vertical of the Great Trigonometrical station. The platform of the latter would have required very extensive repairs, as it is about 12 feet high, and a large part of it had fallen down. Moreover, the station is in the middle of an extensive jungle with no water near, nor any space for tents. The new pillar was 6½ furlongs to the west of the old one, and I found that the prime vertical had been very correctly laid down. It was at this station that I was successful in getting enough pairs to make three programmes.

I had to wait till the 21st before commencing work, as the pillar was not dry enough until that date. I had many interruptions from clouds here, but managed to complete work on the 27th by beginning early, or staying on late after each night's proper programme, so as to pick up stars missed the night before. Sixty pairs of stars were observed on two separate nights and one pair on one night only. The Great Trigonometrical station is slightly higher than the place where my pillar was built, and for a long way round there is not a hill visible; no deviation is therefore to be expected.

I left Darutippa on the 28th and reached Ongole, my penultimate station, on the 4th of March. The Great Trigonometrical station is on a hill some 350 feet high to the north-west of the town. The distance from the sea is only about 10 miles, and every night a very strong wind from the south-east got up and blew till early morning; there was some difficulty in making the observatory secure, but I do not think that the work suffered in any way.

I marched from Ongole on the 19th and reached Danapa, my last station, on the 22nd. The Great Trigonometrical station there is on the top of a rocky hill about 700 feet high. There was no water nearer than about 2 miles from the base, and as there seemed to be no particular object in observing from the top of the hill, I decided to have a new station built in the plain to the east: the distance between the old and new station is 82 chains (1 mile 44 yards). The prime vertical had been very correctly laid down by the sub-surveyor; I was unable to discover any error when I checked it with my instrument,—that is to say, the error must have been less than 10″, which would subtend 3 inches at the distance of 1 mile. The weather at this station was all that could be desired, and I finished my observations on the 30th, having obtained 41 quadruple observations and 4 double ones. The heat by this time was getting very great, and I was very glad to be able to say good-bye to my tents.

The baggage was to be stored in Poona, so I decided to take my final observations for the determination of instrumental constants there. I arrived there on the 12th and took a large number of observations for wire intervals by transits of circumpolar stars; value of micrometer by circumpolar stars at elongation; relative values of micrometer and level by means of a collimator; and for what I have called the "horizontality of the micrometer wire" also by means of a collimator. The necessity for determining this last quantity occurred to me during work. I had adjusted the horizontality of the wire at the beginning of the season, but as I became more accustomed to the instrument, I noticed that the adjustment was by no means perfect, and discovered that I could not further improve it, as I had already exhausted the play allowed to the adjusting block.

So long as the same wire, whether the central one or not, is used for the intersection of both stars of a pair, it will make no difference whether the micrometer wire is truly horizontal or not, but if one star is bisected on the centre wire and the other at any other

point of the field, then, unless the wire is truly horizontal, the micrometer readings will not be truly comparable; my object was therefore to determine what correction should be applied to reduce the micrometer reading of a star bisected at a point other than the centre to what it would have been if bisected at the centre, not for the present considering the small correction on account of the star's extra-meridian position.

The method I adopted was as follows :—I set up a collimator and moved my telescope until the collimator cross appeared on wire I, and intersected with the moveable wire, repeating the operation several times so as to obtain a good value. I then revolved my instrument in azimuth by means of the tangent screw until the collimator cross appeared on wire V, and again intersected with the moveable wire. Had this wire been truly horizontal the readings would have been identical, and the difference observed was a measure of its actual inclination. Knowing the intervals between the wires and the differences in the readings of the micrometer according as the star was on wire I or V, it was easy to discover the correction applicable to a reading taken at any part of the field to reduce it to a reading on central wire.

The weak part of the above process was the turning in azimuth by the tangent screw, and the values deduced after return to recess-quarters did not prove very accordant. To make the values of these corrections more certain, some observations were taken by Mr. McA'Fee in Dehra by a different method. He observed zenith distances of stars of about N. P. D. 25° to 30° at upper transit. The instrument being carefully adjusted in the meridian, it follows that wires I and V would be very nearly equidistant therefrom, so that the zenith distances of a star at the instant of transit over them would be equal, and that the micrometer readings would be equal if the moveable wire was horizontal. This method proved more successful, and the values found by it were used in all cases where one or both stars had been intersected when at a distance from the centre wire.

As the zenith telescope was used for the first time this season, it may be well to give some account of the method of observing adopted. The great difficulty of Talcott's method consists in finding a sufficient number of well-determined stars which form pairs. It was for this reason impossible to get as many determinations of the latitude as used to be obtained with the zenith sector.

With the zenith sector about 100 stars were observed twice each, it being considered that two observations of Z. D. with this instrument gave a value, the precision of which was equal to that of the star's place. With the zenith telescope it was thought advisable to increase this number to four, so that it was decided to observe two programmes on four nights each, making a total of eight nights per station.

Assuming four hours as a fair average night's work, it was found that about 20 pairs could be obtained in that time, and 40 pairs was finally decided on as the minimum number for a station. At some places I was able to obtain a few more, but the number was never greatly in excess of this.

In order to introduce every possible variety of instrumental position, it was decided to proceed as follows:—

1st night, Foot screw A, North.
First star, Telescope East.
Second star, „ West.
2nd night, Foot screw A, North.
First star, Telescope West.
Second star, „ East.
3rd night, Foot screw A, South.
First star, Telescope East.
Second star, „ West.
4th night, Foot screw A, South.
First star, Telescope West.
Second star, „ East.

Foot screw A was one of the screws of the instrument which I had marked A in order to distinguish it.

When I had become familiar with the instrument, it seemed to me unlikely that with so light an instrument these changes would produce much effect on the result and moreover, I had great hope that the results by each pair of stars would not prove very discordant *inter se* so that to multiply the observation of each pair would not tend to diminish the probable error, and I therefore applied for permission, as already related, to alter the procedure, and, when possible, to observe three programmes on two nights, thus saving time and increasing the number of values obtained.

In order to test the propriety of this change, I have calculated the probable error of observation in a single determination of the difference of Z. D. of a pair, and that of half the sum of the declinations of two stars forming a pair as taken from the catalogue, and find that, at Saint Thomas' Mount my first station, the former is 0″477, and the latter 0″502. This shows that it is futile to multiply observations of the same stars, so that the plan of observing each pair only twice, and of increasing the number of pairs observed, is justified. It will often, however, be found impossible to obtain more than about 45 pairs, and with this number it will be best to adhere to the old procedure. Unless about 60 pairs can be obtained, it would probably be injudicious to reduce the number of observations of each.

With the zenith sector, great differences have been observed in the results obtained sometimes by north and south stars respectively, and sometimes according as the stars were observed east—west, or west—east. With the zenith telescope, as each result involves an observation of a north star and also of a south one, no north—south equation was to be expected. It seemed possible, however, that some difference would appear depending on the direction in which the instrument was turned between the observations of the stars of a pair, whether from east to west or from west to east. However, a very careful scrutiny of the results has not brought to light any evidence of the existence of such a law. The mean of all east—west values always agrees closely with that of all west—east values, the differences between them, if any, being irregular in sign and amount, showing that they are entirely accidental.

The results were arranged in several ways in order to test whether there was any discoverable law governing the discrepancies. They were first arranged in descending order of zenith distances, then according to the interval which had to elapse between the two observations forming a pair; thirdly, according to the weight of the star's places as deduced from the number of observations recorded in the catalogue, but no evidence of a system among the discrepancies was discovered. It lastly occurred to me that if the value adopted for a division of the micrometer head were incorrect, a differencwou d appear according as a large $+^{ve}$ or $-^{ve}$ micrometer correction had been applied.

To test this I collected all the results in which $+^{ve}$ corrections had been applied in one column, and all with $-^{ve}$ corrections in another and took means. It at once became apparent that there was an error of this sort. The mean, by positively corrected results, was always considerably smaller than that by negatively corrected ones.

I now added up the amounts of the $+^{ve}$ and $-^{ve}$ corrections and took the mean of each, adding these two means together. It was evident that whatever difference there was between the means of the positively and negatively corrected results, was due to the error in a micrometer division multiplied by the sum so obtained. Thus if :—

Mean +ve correction.	Mean of +vely corrected results.	Mean − ve correction.	Mean of −vely corrected results.
2,000	20·2	2,500	21·0

then the accumulated error of 4,500 micrometer divisions or of 45 revolutions $= 0''.8$.

Therefore the error of 1 revolution $= -\frac{0''.8}{45} = -0''.018$ nearly. The real error in the value of a revolution is twice this amount, for only half the difference of Z. D., as determined by the micrometer, enters into the latitude.

The following table shows the actual results obtained from the different latitudes observed :—

Station.	Error in ½ micrometer revolution.
Saint Thomas' Mount	0″·0191
Madras Observatory	·0252
Gudali Hill Station	·0183
Kistana Hill Station	·0273
Darutippa	·0230
Ongole Hill Station	·0207
Dânapa Hill Station	·0236
Mean	0″·0225

Error of 1 revolution = −·0450

The excellent accordance of these results proves beyond doubt that the adopted value of the micrometer revolution is too small, and it has been assumed that the mean of them, *viz.*,—·0450, is the actual error. On looking at the value and its determination it seems strange that it should be so largely in error, for it is the mean of two values with a probable error of ·005 and ·05 respectively, so that its own probable error is only $\pm 0''.0251$. However, there is very good reason to believe that the cause lies in the refraction applied: the value of this was $0''.19$, and an alteration in the constants of barometric pressure and temperature, which were not applied, could easily produce a difference of $0''.05$. I have attempted to estimate the probable barometer and thermometer heights, and find that the refraction correction was too great by ·040, leaving only ·005 as the correction now to be applied, a quantity well within the probable error. Or, taking only that determination of which the probable error is $0''.005$, the value of one revolution of the micrometer head with the mean refraction correction error is $69''.309$. The value which the present investigation points to as the correct one is $69''.345$. Applying the refraction correction as now determined by assuming heights of barometer and thermometer (27·5 inches and 75° at Poona on April 16th—19th), the first value becomes $69''.349$, which differs from the apparently correct value by $0''.004$, a quantity less than the probable error. These considerations seemed to me to justify the adoption of the new value $69''.345$, and this has consequently been used throughout.

It is worthy of note that had the sums of $+^{ve}$ and $-^{ve}$ micrometer corrections been equal, an error in the value of micrometer revolution would have disappeared in the mean, so that the latitude would not have been affected. This is a condition which it would be

very difficult, if not impossible, to comply with in arranging the programme, but it should not be lost sight of, and it might even be advisable occasionally to reject a few results, so as to bring those amounts into approximate agreement.

The following is a table of the final values, etc.:—

Stations.	Number of pairs observed.	Number of observations.	Astronomical Latitude and probable error $= \lambda_o$.	Geodetic Latitude $= \lambda_c$.	$\lambda_o - \lambda_c =$ apparent deviation of plumb line.
Saint Thomas' Mount . .	40	122	13°— 0′—20″·66±·077	13°— 0′—14″·79	+5″·87
Madras Observatory . . .	40	136	13 — 4 — 9 ·88±·067	13 — 4 — 2 ·06	+7 ·82
Gudali	45	172	14 — 1 —10 ·65±·056	14 — 1 — 9 ·45	+1 ·20
Kistama	45	168	14 —27 —12 ·30±·050	14 —27 —14 ·56	—2 ·26
Darutippa	61	121	15 — 0 —33 ·52±·041	15 — 0 —36 ·47	—2 ·95
Ongole	47	171	15 —29 —52 ·90±·051	15 —29 —56 ·85	—3 ·95
Dànapa	45	172	15 —55 —59 ·70±·050	15 —56 — 0 ·14	+0 ·44

The mean probable error is ±·056.

It will be noticed that the smallest probable error [±·041] occurs at the station where the largest number of stars was observed, although the number of observations at that station was the smallest of all, owing to there having been six nights' work instead of eight. This points clearly to the advantage of increasing the number of stars observed as far as possible, and to the futility of observing the same stars repeatedly. As before remarked, it will probably be found most advantageous to observe each pair twice and not more often. The differences between the astronomical and geodetic values are on the whole less than those found in 1888-89, and the sign is not so constant.

TIDAL AND LEVELLING OPERATIONS.

Extract from the Narrative Report of Lieutenant-Colonel J. Hill, R.E., *in charge No. 25 Party,—Season 1890-91.*

Tidal Operations.

During the survey year under review tidal observations were carried on at seventeen stations, namely, *Aden*, *Kurrachee*, Bhávnagar, *Bombay* (*Apollo Bandar*), Bombay (Prince's Dock), Cochin, Minicoy, Tuticorin, Trincomalee, Madras, Cocanada, *Kidderpore*, Chittagong, Akyab, *Rangoon*, Mergui and *Port Blair*. The eleven tidal stations, whose names are not italicised, are minor stations, where observations, as a rule, are taken for five years only. The six whose names are italicised are *permanent* stations, where the minimum duration of observations is for 19 years, and where observations should be continued until the work at all the stations is completed.

At Madras the tidal observatory worked for only ten days during the year, as it was closed on the 10th October 1890 for reasons given at page 73 of the General Report for 1889-90, and at pages xvii and xviii of its appendix. At Cocanada the observatory was closed on the 18th April and at Chittagong on the 22nd July, five years' observations having been completed at these stations.

Two new tidal observatories were established during the year,—one at Trincomalee and the other at the island of Minicoy. Registrations commenced at the former on the 10th November 1890, and at the latter on the 12th January 1891. Particulars of their establishment will be found further on.

It will be seen from the foregoing, combined with the particulars given in previous annual reports, that since the resumption of tidal operations systematically in 1877, observations have been taken at 31 tidal observatories, of which 17 (including Madras) have been closed on the completion of their registrations and 14 are now in operation.

I shall now describe briefly the working of each observatory, commencing with Aden, and following the order of the stations round the coasts to Burma:—

Aden.—It is disappointing to have to report that the recent tidal observations at this important station have been of a very unsatisfactory nature. I left India on leave in May 1888, at which time the observatory was one of the most satisfactory in operation; but when I returned to India in November 1890 I found it the most unsatisfactory. This I am obliged to attribute not only to the carelessness of the observatory clerks, but to the lax supervision of the Port Officer. Aden is one of the permanent tidal stations which have all to be kept up as long as the general tidal operations continue, and at which it is important that there should be no break in the continuity of the registrations. During the eleven years extending from March 1879, when the station was permanently established, to March 1890, the registrations at Aden were continuous and satisfactory. Since the latter date, although the gauge has continued to work almost without interruption, its registrations have in many cases been rendered useless, owing chiefly to the diagrams having sometimes been wrongly adjusted, and to the driving clock having been damaged through too frequent tampering with it in order to regulate it; the result being that, except for making a few comparisons between actual and predicted tides, a whole year's tidal regis-

trations (from March 1890 to March 1891) were rendered useless, and have had to be rejected, thus causing a most serious break in what ought to have been a continuous series. The actual working of the auxiliary instruments at Aden was on the whole fairly satisfactory; but, for two periods of about a fortnight each, the readings of the barometers and thermometers were incorrectly taken by the observatory clerk. The error of the tide gauge clock was also incorrectly recorded by him on several occasions; and these faults, which ought to have been at once detected in Aden, were only discovered in my office when the daily reports arrived there. The attention of the Port Officer was drawn to these circumstances. The observatory was inspected towards the end of last March by Mr. Belcham, who put all the instruments into good order and adjustment, and since his inspection the work of the observatory has been proceeding satisfactorily.

Kurrachee.—At this station the record of the year's work is very satisfactory. The tide gauge worked practically without a break, only one short interruption worth mentioning having occurred on the 11th January, when the inlet holes of the cylinder were blocked for 15 hours. The auxiliary instruments also worked most satisfactorily; except when they were being cleaned their registrations were absolutely uninterrupted. For the continued efficiency of this observatory my thanks are due to Mr. Morris, the Port Engineer. He takes a great interest in the tidal observations, and continues the arrangements made by his predecessor who appointed Mr. Dharam Sing, Assistant Engineer, to make frequent visits to the observatory and take measurements for determination of zero, etc., when necessary, and provided for the ordinary cleaning and repairing of the instruments by a skilled mechanic. I inspected the observatory in December, and found all the instruments in perfect order, except that the rack and pinion moving the reading vernier of the standard mercurial barometer had to be repaired.

Bhávnagar.—The working of this observatory has been satisfactory on the whole. Apart from the usual interruptions caused by flushing the cylinder, and one special interruption of five days while a portion of the inlet pipe was being renewed and the cylinder cleaned and painted, the accidental interruptions of the registrations were few and trivial. One accident to the tide gauge, however, occurred during the year. While the cylinder was being flushed on the 22nd August the float band broke; but it was immediately repaired, and zero measurements at once taken by the Assistant State Engineer proved that the working zero of the instrument had not undergone any change. All the auxiliary instruments worked well, except the self-registering aneroid, which worked imperfecty throughout the whole year. The usual readings of the standard mercurial barometer have, however, been taken uninterruptedly, and supply the necessary barometric information. This observatory was not inspected during the year under report: it will therefore be expedient to make an inspection of it early in the survey year 1891-92.

I am indebted to Mr. Proctor Sims for his co-operation, to which the success of the tidal observations at Bhávnagar is entirely due.

Bombay (Apollo Bandar).—At this observatory the tide gauge has as usual worked extremely well, and no interruptions of the registrations occurred during the year. The driving clock was under repair for two days in October last; but the height of the tide was marked upon the drum every quarter of an hour during that time, thus avoiding a break in the observations. The observatory was inspected by me in December, when the gauge was found in very good order. The new graduated staff however was found not to work satisfactorily, and I recommended its removal and the substitution of another of a different construction.

Auxiliary instruments are not used or required at either of the Bombay tidal observatories, as the meteorological observations are taken at the Colaba observatory.

Bombay (Prince's Dock).—The tide gauge at Prince's Dock differs in construction from those in use at all the other Indian observatories, its drum for recording the tidal curves being vertical, and its mechanism not being so simple as that of the usual pattern. Its working on the whole has been satisfactory. There have been only three interruptions to its registrations during the year, none of which exceeded 17 hours in duration; the first was due to an accident to the cord of the clock weight, the second to an accident to the pencil wire, and the third, which occurred so lately as the 29th September, was caused by a rupture of the float band. The arrangement of the pencil markers in this pattern of gauge is not entirely satisfactory: it resulted on three occasions in the zero pencil sticking in the diagram and tearing it for a short distance. I inspected the observatory in August, when, although the gauge required cleaning, everything was found in good working order. My acknowledgments are due to the Engineer and the Assistant Engineer of the Port Trust for their continued interest in the tidal observations at both of the Bombay observatories, and for the assistance they are always so ready to give me, to which is due the fact that the tidal station of Bombay ranks first not only as regards continuity of the observations, but as regards the excellence of the results obtained therefrom.

Cochin.—The tidal registrations at this station were perfect throughout the year. The registrations of the aneroid barometer were nearly so, as only one short interruption lasting ten hours, due to the stoppage of the clock, occurred. The anemometer also worked very well, its registrations having experienced only three very short interruptions, none of them exceeding 5 hours in duration. The observatory was inspected in February by Mr. Belcham, who found it in order, and all the instruments working satisfactorily. The last 2 feet of the inlet pipe at its outer end had however become corroded and required renewal. This could not be done at the time owing to the height of the water

in the river, but during the time of lowest low water in May the corroded part of the pipe was removed, and replaced by new piping by Captain Winckler, the Port Officer, to whom our thanks are due for the great care he has exercised over the observatory ever since its establishment

Minicoy.—This new tidal station is situated in the island of the same name, which is a small coral island lying off the Malabar coast, between the Laccadive and Maldive islands, 270 miles west of, and in about the same latitude as Cape Comorin. It divides the 8 and 9 degree channels in 73° East longitude, and lies right in the track of steam vessels from Ceylon to Aden, for whose benefit a light-house has been erected at the south-westerly extremity of the island. The island which is well planted with cocoanut trees is a long, bent, narrow strip of low land, the southern and broadest portion (about 900 yards wide) extending from west to east for about two miles, then forming an elbow, from which a narrow portion trends in a north-easterly direction for about an equal distance, until a rather wider spot is reached, where the village of Minicoy has been built; from this spot the land tapers away for a further distance of 3 miles in a north-north-east direction, this part of the island being not more than 200 yards broad.

An irregular coral reef, bare at low water and lying about three miles away to the westward of the village, bends eastwards at each of its ends and joins itself to the extremities of the island, forming with it a roughly pear-shaped lagoon (the wider part being to the south), at the south-west end of which is a small islet with trees, distant about half a mile from the lower extremity of the main island, where the light-house is situated. The continuity of the reef is broken at three places, *viz.*, at the northern extremity of the island, where there is a narrow and intricate passage, in no part deeper than 2 fathoms, through which boats and small vessels pass in and out of the lagoon, and at two spots opposite the village, and distant from each other nearly two miles, at each of which there is a gap just wide enough to allow fishing boats to pass through. The general position of the village has been mentioned: it is built on the margin of the lagoon, and is protected from any encroachment of the sea on its eastern side by an artificial embankment, in some places 20 feet high, which extends from it in each direction along the outer shore for a distance of about a mile. Minicoy is under the jurisdiction of the Collector of Malabar, whose head-quarters are at Calicut.

The tidal observatory is situated in the lagoon, 110 feet from the bank, and directly opposite the Kacheri, which is at the southern end of the village. The tidal instruments are contained in a small wooden house, 10 feet square, resting on a stout horizontal framework of cocoanut-wood beams, which also binds together the tops of 9 cocoanut piles which support the structure. These piles vary in length from 16 to 17 feet, and are driven well into the sand and coral and firmly braced together, and to make the whole structure as strong as possible, long iron bolts with nuts have been used to join the frame of the house to the framework surmounting the piles: a bridge of almond-wood, supported on cocoanut piles, connects the observatory with the shore. A very massive iron drainage pipe, purchased at Colombo, 12½ feet long and 20 inches in internal diameter, serves as a float cylinder: its bottom is plugged with a perforated wooden disc and rests on a large stone, 36″ × 30″ × 14″, the upper surface of which has a circular groove to receive the bottom rim of the cylinder. Under the centre of the cylinder the stone is hollowed out and connected by openings on each side with the external water, which has thus free communication with the float. A graduated staff, 8½ feet in length, divided into tenths of feet and set to the same zero as the tide gauge, is fixed to one of the piles of the observatory to act as an independent check on the registrations of the gauge. For regulating the tidal observatory clocks, one of the new pattern sun-dials, designed by Colonel G. Strahan and constructed at Dehra Dun, has been set up on the shore within a few feet of the communication bridge.

The instruments at work in the tidal observatory consist of a self-registering tide gauge of the new pattern (No. 23, by Adie), by which the tidal curves are reproduced on a scale equal to one-half the natural magnitude, a self-registering aneroid barometer by Légé & Co., and a mercurial barometer (No. 1308, by Casella): in addition to these a rain gauge has been fixed on a post near the sun-dial pillar, and a self-registering anemometer has been set up in a wooden house supported on piles, on an elevation formed of coral, about a mile to the north of the village, where the island is particularly free of tall trees. The site for the observatory was selected by Mr. Belcham early in 1890; and the greater part of the instrumental equipment and the timber house (formerly at Okha, Pamban and Colombo), which it was intended to set up, were taken to Minicoy from Colombo in October by Lieutenant Channer, R.N.: subsequently that officer landed Mr. Belcham on the island on the 14th December, together with the senior mechanic of the party, two tidal observatory clerks, and the remainder of the instruments.

Cocoanut piles which had been ordered through the Collector of Malabar were found ready, so Mr. Belcham experienced no delay in setting to work, and the instruments commenced their registrations on the following dates:—the tide gauge on the 12th, the aneroid on the 20th, and the anemometer on the 22nd January 1891. After satisfying himself that everything connected with the observatory was in thorough order, and that the clerks understood all their duties, Mr. Belcham left the island for Colombo with Lieutenant Channer on the 7th February. On the beach near the sun-dial pillar, a small thatched house, 10 feet square, was erected, in which a set of meteorological instruments were set up at the request of the Meteorological Reporter to the Government of India: these instruments are read daily

at specified times by the clerk in charge of the tidal observatory, and the records are sent to the Meteorological Reporter.

Lieutenant Channer, R.N., the Superintendent of Light-houses, visits the island every six weeks in fair weather and at longer intervals during the south-west monsoon. We are greatly indebted to him for his assistance and for his having very kindly undertaken to bring away the records and reports from the observatory and post them at Colombo.

During the year under report the tide gauge and all the auxiliary instruments have been working very satisfactorily, with the exception of the anemometer, which stopped six times, for about 12 hours at a time, up to the 4th March, from which date its record is continuous and satisfactory.

The tidal observatory is in charge of Mr. J. S. Francis, the senior observatory clerk, who had four years' experience in the tidal observatory at Cocanada, and who, having performed his duties there very carefully and well, was selected for employment at Minicoy. An assistant clerk is also attached to the observatory, as in such an isolated place it would be unwise to allow the registrations to depend on the health of a single clerk.

Tuticorin.—Here the tide gauge has worked very satisfactorily throughout the year, its record having been almost uninterrupted. On one day only two short interruptions took place, caused by the counterpoise chain of the float sticking at the bottom of the cylinder. The work done by the aneroid and anemometer has also been most satisfactory, no accidental interruption of any kind having occurred.

An inspection of the observatory was made from the 16th to the 22nd February by Mr. Belcham, who found the several instruments in good order, with the exception of the mercurial barometer, the cistern of which he noticed on the morning of the 17th February to contain about a tenth of an inch of water, which must have got in during a heavy downpour the night before; the water was removed and the whole of the instruments were cleaned and left in good order. I am indebted to Captain Baker, the Port Officer, who continues to take a great interest in our work, for the kind supervision he exercises over the observatory. A circumstance worth mentioning is that during the spring tides of the 23rd, 24th and 25th June, which were accompanied by strong south-west winds, the water fell to a very low level. On the morning of the 24th the tidal curve reached a depth of one inch below the zero of the gauge, which is the first instance of the curve passing below the zero during the three years the gauge has been in operation at Tuticorin. The range of the tide was at the same time below the average, the immediately preceding and succeeding high waters being 2′ 11″ and 2′ 0″ respectively, above the zero of the gauge: while the mean value of the range at springs is 3·2 feet.

A peculiarity of the tides in the Gulf of Manar is that, contrary to what might be expected, the mean sea-level during the south-west monsoon is considerably lower than during the south-east monsoon. The yearly mean range of the tide in the Gulf is less than two feet; but during August the monthly mean value of mean sea-level falls lower than during December by as much as 10·6 inches. It will thus be seen that tidal observations taken during one lunation only, may not, as it is sometimes assumed they do, supply a good working value of mean sea-level for spirit-levelling purposes.

Trincomalee.—The position selected for this new tidal station on the north-east coast of Ceylon, is in the Naval Dockyard on the east side of Trincomalee Harbour. The tidal observatory is approximately in latitude 8° 33′ North, longitude 81° 13′ East. The arrangements for its establishment were made last year, and were mentioned in the General Report for 1889-90, and the observatory house, which was constructed under the superintendence of Mr. DeRidder, the Naval Store-keeper, was completed and made over, about the end of October, to Mr. Belcham, who started the work on the 10th November.

The observatory house, which is 12 feet square, with wooden walls and a tiled roof, is constructed on the pattern of the observatories at Tuticorin, Akyab and Mergui, and is situated on the small stone wharf at the south end of the Naval Dockyard, adjoining the Chief Clerk's house: it is very neatly and strongly put together; half of the building rests on the wharf wall, to which it is secured by iron bolts, while the other half which projects beyond the wharf is supported by three iron struts thrown out from the wall. The float cylinder is a massive iron drainage pipe, similar to the one at Minicoy; it is 12½ feet in length and 20 inches in internal diameter, one foot four inches of which is above and the remainder below the level of the observatory floor; its bottom is closed with a plug of iron-wood, containing five perforations, each an inch in diameter, for the inlet and outlet of the water, and rests on three stout iron pegs, which project about nine inches above the bed of the harbour. A vertical graduated staff, six feet in length, divided to 10ths of a foot, was attached to the house and to the iron strut on the north side of the observatory, having its zero identical with that of the tide gauge to check the height of the water which should always be the same inside and outside the cylinder.

The self-registering tide gauge, aneroid barometer, anemometer and the mercurial barometer are placed in the tidal observatory, while the rain gauge is fixed on the north-west corner of the compound wall of the Chief Clerk's house. The observatory clocks are kept to correct mean time by comparisons made twice a week with telegraph time, which is signalled, as a rule, daily at 4 P.M. from Madras. The tide gauge by which the curves are reproduced on the natural scale has worked most satisfactorily up to date, no interruption of any kind having taken place.

The aneroid has worked continuously since it was started, and the barometric curve is correctly recorded. The registrations by the anemometer, however, have not been satisfactory; the instrument worked steadily for a month after being set up, *viz.*, to the 13th December, on which day the clock got out of order, and there were no less than 24 interruptions up to the 18th June, one of which lasted four days, and the remainder caused breaks in the record ranging from 4 to 15 hours, but since the latter date no further stoppages were reported until September, during which month two interruptions occurred, lasting respectively 14 and 16 hours.

Mr. W. D. Sarasinha, who formerly carried on the duties of observatory clerk at Galle, was appointed to this observatory, and remained in charge until the 22nd March, when he became ill and resigned and another Cingalese, named Arunasalem, who had been taught by him, was appointed in his place. Mr. DeRidder supervises the working of the observatory, and our thanks are due to him for the great trouble he is taking to ensure the success of the observations.

Madras.—As previously mentioned, this tidal observatory worked for only 10 days during the year under report, *viz.*, from the 1st to the 10th October. It will be unnecessary for me to report on the observations taken during this short period, as Mr. Wood brought his report on Madras, in last year's Annual Report, up to the latter date. It had been intended to continue the registration to the 4th November; but Mr. Wood remarked in the report just mentioned (*vide* appendix to General Report for 1889-90, p. xviii) :—

"I regret that a little undue haste on the part of the authorities responsible for the repairs to the pier head, induced the Presidency Port Officer to actually close the observatory on the 10th October, before apprising me of it."

The Madras Government have been led to abandon their intention of continuing tidal observations at Madras (although their costly new instruments for doing so are now lying there in store ready for erection), owing to the inconvenience that would be occasioned, by a tidal observatory of a needlessly elaborate and expensive design submitted to them being placed in the new harbour works in a position which they consider would interfere with and reduce the berthage inside the harbour. I see no reason why an observatory should not be constructed on the new harbour works which would not reduce the berthage at all or interfere with traffic of any kind, and which could be built at a very reasonable cost; and I shall ascertain whether the Madras Government would consent to re-open this question. It is desirable that with proper instruments suitably placed we should obtain good tidal registrations similar to those obtained at Bombay and other important ports, instead of the very inferior measurements altogether unworthy of the port of Madras, which were taken for a series of years with an inferior apparatus at an objectionable site, and which are now discontinued. I may add that in less than two years, unless the Madras Government consent to reconsider their decision, there will not be a single tidal observatory in operation along the whole eastern coast of India, which I think would be very regrettable.

Cocanada.—The usual five years' registrations having been completed at this minor station on the 18th April 1891, the observatory was then dismantled by sub-surveyor Dhondu Vinayek. The tide gauge worked satisfactorily during the year under report, not a single interruption having occurred; in fact from the commencement to the close of the observations there have been but four short interruptions on the record, all of them due to the float band slipping off the stud wheel: the tidal registrations may therefore be said to be continuous and most satisfactory throughout the whole period of the observations.

The aneroid barometer had been reported last year as being very insensitive; and as it continued so, it was not kept at work during the year under report: in fact the record of the aneroid from the beginning of the observations is worthless, owing to a defect in the instrument which prevented the diurnal variations of pressure from being correctly indicated; there is however a complete record of the readings of the standard mercurial barometer taken daily at 7 and 10 A.M. and at 4 and 6 P.M. throughout the five years of observation. The anemometer has worked satisfactorily throughout the observations, there having been only two short interruptions in its record for the present year, and only a few others in the previous four years. The tide gauge, anemometer and mercurial barometer have been left, carefully packed, in the Port Office at Cocanada ready for transmission to the station where they may be required, while the aneroid barometer was brought away to Poona to be repaired if possible.

During the time the observatory was being dismantled, a graduated staff, 8 feet in length, divided into feet and inches, and having its zero set to the datum of the tide tables, was attached to one of the piles of the Port Office jetty, for taking personal observations of the height of the water at one high and one low tide daily: these observations are being taken regularly under the direction of the Port Officer since the tide gauge was dismantled, and are sent by him monthly to my office for comparison with the values given in the Tide Tables. My thanks are due to Captain Wicks, the Port Officer, for the deep interest he took in the regular observations while the tide gauge was at work, and for his courtesy in now having the graduated staff read daily.

Kidderpore.—During the year under report there have been sixteen interruptions in the record of the tide gauge, all caused by the stoppage of the driving clock from oscillation of the observatory; but as they in no instance exceeded 12 hours in duration, they are unimportant; the wire attached to the counterpoise of the pencil traveller, also that

of the back lash weight, broke once ; but as they were instantly repaired, no loss of work was thus occasioned. The clock of the aneroid stopped twice between the 1st October and 18th November. The instrument was removed on the latter date to the Mathematical Instrument Office for examination and was replaced in position on the 22nd November, after which the clock stopped four times up to the 8th January, when it was cleaned and set in order during my inspection of the observatory, and since then no interruptions have been reported. The only failure in the working of the anemometer for the year occurred on the 11th August, when for three hours, owing to some fault in the spirals, the diagram was not marked.

A regular inspection of this observatory was made by me in January, when the several instruments were thoroughly cleaned and left in good order. In May Mr Belcham, while passing through Calcutta, visited the observatory and laid down two new bench-marks at the entrance to the new dock in place of the old bench-mark of reference, which the Dock Engineer asked for permission to remove, and in August, Mr. Belcham again made a brief inspection of the observatory, and checked the relative levels of the bench-marks he laid down in May. The work carried on in this observatory is supervised by Lieutenant Petley, R. N., the Port Officer and Deputy Conservator of the Port of Calcutta, to whom my thanks are due for the efficient working of the observatory.

Chittagong.—At this minor station five years' observations were completed on the 13th June, but the observatory was not dismantled until the 22nd July. The tide gauge worked regularly during the year under report, with but two very short interruptions ; the driving clock however has not been keeping very good time, the error in sixteen instances being slightly in excess of that allowed. On the whole, however, the observations at this station throughout the five years the instrument has been at work have been very satisfactory. The registrations by the aneroid have been continuous, while those by the anemometer contain two short breaks of a few hours each, and from what has been said about the working of these instruments in former reports, it may be concluded that the record of each is also satisfactory for the five years they have been in operation.

The usual yearly inspection of this observatory was made in March by sub-surveyor Dhondu Vinayek, who found the several instruments working well, and after having them all cleaned by the assistant mechanic of the party, left them in adjustment. Another inspection was made in July by Mr. Belcham, who dismantled the observatory and fixed a graduated staff, 20 feet in length and divided into foot and 3-inch spaces against one of the piles of the iron jetty. The staff, which has its zero the same as the datum of the tide tables for Chittagong, is read twice daily at high and low water by one of the clerks in the Port Office, and the readings are compared in this office with the predicted values.

The aneroid barometer, anemometer and rain gauge were carefully packed and stored in the Port Office godown at Chittagong, but the mercurial barometer and tide gauge were taken to the Rangoon tidal observatory by Mr. Belcham, who set up the barometer and attached the driving 'regulator clock,' with English lever escapement, to the Rangoon tide gauge in lieu of its own pendulum clock which, together with the other portions of the Chittagong gauge, were packed and stored in the Rangoon Port Office godown, along with the set of instruments from the Elephant Point tidal observatory, to await transmission to other stations.

The observations taken in the tidal observatory have been supervised throughout the five years by Mr. Good, the Port Officer, and I am much obliged to him for the good results obtained from them, and for the interest he continues to take in having the graduated staff read daily.

Akyab.—No interruptions to the working of the tide gauge occurred, except two trivial ones, one lasting two and the other four hours ; and of the auxiliary instruments the registrations of the aneroid and the anemometer were equally perfect. The rain gauge however failed to register the proper amount of rainfall owing to its reservoir not being sufficiently capacious, but this is not of much importance as there is a meteorological observatory at the Government Telegraph Office, where the rainfall has been correctly measured.

The observatory was inspected by sub-surveyor Dhondu Vinayek in February, when he found all the instruments in good order. A subsequent brief inspection was made by Mr. Belcham while on his way from Chittagong to Rangoon. He found all the instruments in adjustment; but noted and reported the above mentioned defect in the rain gauge, which was brought to his attention by Captain Pryce, the Port Officer, to whom my thanks are due for the interest he takes in the observations and the supervision he exercises over the observatory.

Rangoon.—At this station the tidal observatory instruments had to be moved to new sites on two occasions during the year under report. From the 1st March 1880 the tidal observatory had occupied one position on Latter Street Wharf; but on the 14th of last April, as it interfered with the extension of the wharf, the observatory had to be temporarily moved a distance of 45 feet. The removal and re-adjustment of the gauge occupied three days, and it remained at work in its new position on the wharf from the 17th April to the 24th June. On the latter date, according to arrangements previously made with the Port Commissioners, the tidal instruments were finally removed from Latter Street Wharf, and on the 4th July they were set up in a new detached observatory which had been prepared for their reception by the Port Engineer between Brooking Street Wharf and Spark's Street Jetty, and which is very conveniently situated in the river opposite the Port Engineer's Office. The new observatory is a substantial, neatly made

wooden structure, 13 feet 9 inches long by 12 feet 6 inches wide by 11 feet high at the eaves, supported on 4 iron screw piles braced togetner by iron tie rods. It is connected with the bank by a strong wooden bridge 100 feet long and 4½ feet wide.

At present the observatory is not free from oscillation caused by the force of wind and water, because during its erection the height of the water rendered it impossible to complete the lower bracing of the piles; but when the river falls to its lowest level, about February, the work will be completed. After commencing work at the observatory the oscillations were frequently so severe as to endanger the pendulum clock, which had driven the gauge during the past 11 years at Latter Street Wharf. The pendulum had on such occasions to be removed, and the drum had to be turned by hand until the oscillations moderated. This inconvenient arrangement was only temporary. The Chittagong tidal observatory had recently been closed, and its clock, which was a 'regulator clock,' with English lever escapement, became available for use in Rangoon. The pendulum clock was removed and the Chittagong clock substituted for it on the 2nd August, since which date no further trouble has been experienced from the oscillations of the observatory. Owing to the precautions taken to avoid breaks in the observations while the gauge was unable to work, the registrations throughout the year are practically continuous.

With regard to the auxiliary instruments. The aneroid worked well as long as it remained at Latter Street Wharf; but since its removal to the new observatory, the oscillations already mentioned have hindered its registrations from being as satisfactory as could be desired. The anemometer still remains at Latter Street Wharf, and its registrations have been satsfactory. The mercurial barometer got out of order on the 25th June during its removal from Latter Street Wharf. On the 29th June an instrument was lent by Mr. Darlington, which was read daily until the 5th August, when the mercurial barometer brought away from the Chittagong tidal observatory was set up and the damaged instrument was taken to Calcutta for repair. A meteorological observatory is being constructed close to the new tidal observatory in the compound of the Port Engineer's Office, which will probably obviate the necessity of our continuing to use auxiliary instruments at the tidal observatory.

The observatory at Latter Street Wharf was inspected in January by sub-surveyor Dhondu Vinayek. It was again inspected and then dismantled by Mr. Belcham in June, and re-established by him in its new site in the following month. I am indebted to Mr. Darlington, the Vice-Chairman of the Port Commissioners, and to Mr. Reichenbach, the Port Engineer, for the interest they take in our operations, and for the trouble they have gone to in order to render them successful.

Mergui.—The registrations of the tide gauge may be pronounced satisfactory; for, although there were eight interruptions to them during the year, they were all trifling, the longest not exceeding eight hours. Six were due to the pencil traveller sticking between its directing bars, one to the breakage of the cord carrying the weight of the driving clock, and one to the breakage of the counterpoise chain of the float band. The registrations obtained from the auxiliary instruments have not been equally satisfactory. There were ten breaks in the aneroid observations, eight of which were caused by boats dashing against the observatory, and giving shocks to it strong enough to stop the aneroid clock, and two by the sticking of the hands of the clock. In order to save the observatory from damage by boats and from shocks of the kind just mentioned, it was decided to protect it by an outer barrier formed of four stout piles strongly braced together with horizontal beams. This protecting barrier was erected early in January, since which time no break in the observations due to shocks has occurred.

The anemometer may be said to have worked uninterruptedly; two very short stoppages of the clock having caused the only breaks throughout the year; but, owing to a part of the mechanism having worn away, the velocity of the wind was not marked from 15th June to 18th August, on the latter of which dates the instrument was repaired.

The observatory was inspected by sub-surveyor Dhondu Vinayek towards the end of January, after the protecting barrier had been erected. He found the observatory and instruments in good order. My acknowledgments are due to Mr. Batten, Deputy Commissioner of Mergui, for continuing the supervision of the observatory so well exercised by his predecessor, and to Mr. Darlington, the Vice-Chairman of the Port Commissioners of Rangoon, for his kindness in allowing one of his Customs clerks, who had formerly learnt the duties of a tidal observatory clerk at Rangoon, to perform the duties of tidal observatory clerk at Mergui.

Port Blair.—I am glad to be able to report that at this station the registrations by the tide gauge have been most satisfactory, not a single interruption having taken place during the year; moreover, the water communication with the float, which had been reported in the last annual report as being retarded to the extent of a foot in height and an hour in time, has been found on examination of the diagrams to have been perfectly free. The aneroid barometer has also worked most satisfactorily, and its record is quite complete.

The anemometer worked continuously from the 1st October to the 17th December, when it was damaged and rendered useless by a shot from a rifle fired by one of the soldiers in the barracks, on the tower of which the instrument had been at work since April 1880. On the 16th May a new instrument was set up, the record of which up to date has only two interruptions, one of 9 hours on the 9th July and one of 20 hours on the 11th July, both caused by the stoppage of the driving clock. The register of the wind for the five months during which the instrument was standing disabled was obtained from the record kept by the Medical Department of Port Blair.

Table showing the mean amplitudes (H) in feet and mean epochs (K) in degrees for each particular tide, which have been calculated from the values obtained

Station.	Year.	S_0 or Height in feet of Mean Level of the above Year.	S_1		S_2		S_3		S_4		S_5		M_1		M_2		M_3		M_4		M_5		M_6		K_1		K_2		P_1		J_1		Q_1		L_2		N_2	
			H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K
Mornington	1883-84	2·312	0·080	110° 12′	0·040	358° 30′	0·006	244° 12′	0·005	214° 12′	0·005	84° 36′	0·005	80° 60′	0·006	200° 24′	0·006	48° 0′	0·006	264° 0′	0·005	34° 48′	0·005	204° 48′	0·060	83° 24′	0·015	83° 24′	0·020	83° 24′	0·005	83° 24′	0·005	83° 24′	0·005	83° 24′	0·005	83° 24′
	1884-85	2·312	0·080	110° 12′	0·040	358° 30′	0·006	244° 12′	0·005	214° 12′	0·005	84° 36′	0·005	80° 60′	0·006	200° 24′	0·006	48° 0′	0·006	264° 0′	0·005	34° 48′	0·005	204° 48′	0·060	83° 24′	0·015	83° 24′	0·020	83° 24′	0·005	83° 24′	0·005	83° 24′	0·005	83° 24′	0·005	83° 24′
	1885-86	2·312	0·080	110° 12′	0·040	358° 30′	0·006	244° 12′	0·005	214° 12′	0·005	84° 36′	0·005	80° 60′	0·006	200° 24′	0·006	48° 0′	0·006	264° 0′	0·005	34° 48′	0·005	204° 48′	0·060	83° 24′	0·015	83° 24′	0·020	83° 24′	0·005	83° 24′	0·005	83° 24′	0·005	83° 24′	0·005	83° 24′
	1886-87	2·312	0·080	110° 12′	0·040	358° 30′	0·006	244° 12′	0·005	214° 12′	0·005	84° 36′	0·005	80° 60′	0·006	200° 24′	0·006	48° 0′	0·006	264° 0′	0·005	34° 48′	0·005	204° 48′	0·060	83° 24′	0·015	83° 24′	0·020	83° 24′	0·005	83° 24′	0·005	83° 24′	0·005	83° 24′	0·005	83° 24′
Means		2·312	0·080	110° 12′	0·040	358° 30′	0·006	244° 12′	0·005	214° 12′	0·005	84° 36′	0·005	80° 60′	0·006	200° 24′	0·006	48° 0′	0·006	264° 0′	0·005	34° 48′	0·005	204° 48′	0·060	83° 24′	0·015	83° 24′	0·020	83° 24′	0·005	83° 24′	0·005	83° 24′	0·005	83° 24′	0·005	83° 24′
Galle	1883-84	2·726	0·021	31° 12′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1884-85	2·726	0·021	31° 12′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1885-86	2·726	0·021	31° 12′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1886-87	2·726	0·021	31° 12′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Means		2·726	0·021	31° 12′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Colombo	1883-84	2·708	0·026	81° 36′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1884-85	2·708	0·026	81° 36′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1885-86	2·708	0·026	81° 36′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1886-87	2·708	0·026	81° 36′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Means		2·708	0·026	81° 36′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
St. Paul's	1883-84	2·696	0·048	0° 0′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1884-85	2·696	0·048	0° 0′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1885-86	2·696	0·048	0° 0′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1886-87	2·696	0·048	0° 0′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Means		2·696	0·048	0° 0′	0·010	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Madras	1883-84	2·521	0·051	80° 24′	0·021	357° 36′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1884-85	2·521	0·051	80° 24′	0·021	357° 36′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1885-86	2·521	0·051	80° 24′	0·021	357° 36′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1886-87	2·521	0·051	80° 24′	0·021	357° 36′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Means		2·521	0·051	80° 24′	0·021	357° 36′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Cocanada	1883-84	2·466	0·056	84° 36′	0·021	357° 36′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1884-85	2·466	0·056	84° 36′	0·021	357° 36′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1885-86	2·466	0·056	84° 36′	0·021	357° 36′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1886-87	2·466	0·056	84° 36′	0·021	357° 36′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Means		2·466	0·056	84° 36′	0·021	357° 36′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Chittagong*	1883-84	2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1884-85	2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1885-86	2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1886-87	2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Means		2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Elephant Point*	1883	2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1884	2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1885	2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1886	2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
	1886-87	2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′
Means		2·344	0·080	120° 36′	0·030	0° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′	0·005	180° 0′

* These are Harmonic Stations at which A_0 is the height of mean level of the water above zero.

Statement showing the interruptions which occurred in the observations entered in S Series.

Name of Station.	Year of Observation.	Period of interruption. From	To	Total Number of days' interruption. In each period.	In the year.	Name of Station.	Year of Observation.	Notes.
Galle	1883-84	5th September 1884	15th September 1884	11	11	Madras	1883-84	13th February 1884
	1884-85	27th July 1885	3rd August 1885	8	8			22nd July 1884
	1885-86	15th December 1885	26th January 1886	42	55			29th July 1884
		27th January 1886	31st January 1886	13			1884-85	13th February 1885
Colombo	1883-84	30th September 1884	31st October 1884	31	31			30th October 1884
	1884-85	15th July 1885	31st July 1885	17	17		1885-86	13th February 1886
	1885-86	1st December 1885	31st December 1885	31	31			14th May 1886
	1886-87	21st October 1886	21st November 1886	32	32		1886-87	14th May 1887
Singapore	1886-87	1st December 1886	15th December 1886	15	15			15th May 1887
Chittagong	1884-85	1st December 1884	31st December 1884	31	31		1886-87	30th May 1887
Elephant Point	1884	5th November 1884	30th November 1884	26	26		1886-87	31st May 1887

btained by Tidal observations each year at the stations where the operations are completed.

ν_2		μ_2		T_2		$(MS)_4$		$(SM)_4$		$2N_2$		$(M_2N)_4$		$(M_2K_1)_3$		$(M_2K_1)_3$		Lunar Monthly.		Lunar Fortnightly.		Luni-solar Fortnightly.		Solar-annual.		Solar Semi-annual.		STATION.
H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	
2153	278°·16	0°·062	247°·48	...	...	0°·032	59°·73	0°·062	201°·24	0°·063	238°·89	0°·045	342°·36	0°·019	335°·89	0°·009	350°·96	0°·048	74°·73	0°·048	13°·65	0°·021	15°·39	0°·306	306°·36	0°·075	162°·37	
2104	253°·39	0°·042	246°·35	0°·068	177°·82	0°·008	63°·22	0°·043	158°·45	0°·069	262°·34	0°·057	341°·35	0°·033	33°·64	0°·006	29°·69	0°·029	258°·55	0°·073	13°·91	0°·057	279°·30	0°·061	333°·21	0°·055	69°·51	
2102	253°·97	0°·048	248°·39	...	...	0°·028	44°·40	0°·040	70°·18	0°·074	258°·57	0°·033	350°·98	0°·033	108°·51	0°·005	0°·35	0°·035	68°·62	0°·067	11°·34	0°·041	354°·01	0°·051	353°·58	0°·133	65°·38	
2102	253°·97	0°·048	248°·39	0°·073	357°·21	0°·026	50°·60	0°·040	70°·18	0°·074	258°·57	0°·026	4°·55	0°·010	139°·67	0°·008	0°·35	0°·027	153°·63	0°·010	258°·90	0°·036	80°·16	0°·036	80°·16	0°·130	175°·30	
2157	301°·90	0°·064	262°·26	0°·069	342°·59	0°·031	39°·70	0°·011	121°·40	0°·062	228°·40	0°·039	16°·85	0°·020	349°·34	0°·007	69°·02	0°·020	300°·58	0°·068	342°·72	0°·025	305°·83	0°·026	304°·14	0°·128	139°·88	
2156	280°·43	0°·053	250°·47	0°·079	315°·84	0°·004	47°·37	0°·006	136°·32	0°·063	250°·08	0°·046	351°·73	0°·026	37°·21	0°·007	30°·00	0°·030	9°·24	0°·069	30°·07	0°·031	275°·74	0°·069	313°·34	0°·116	138°·47	Mormugão.
2048	66°·52	0°·025	101°·83	...	...	0°·006	314°·74	0°·007	25°·69	0°·007	208°·91	0°·006	164°·07	0°·003	164°·07	0°·001	135°·25	0°·067	21°·93	0°·020	12°·20	0°·013	324°·44	0°·037	314°·15	0°·052	114°·73	
2054	49°·84	0°·017	96°·51	0°·041	352°·06	0°·005	24°·89	0°·005	340°·03	0°·012	122°·83	0°·004	256°·16	0°·002	256°·16	0°·001	180°·26	0°·055	0°·97	0°·017	11°·14	0°·009	13°·17	0°·027	239°·35	0°·039	86°·07	
2053	76°·34	0°·026	102°·45	...	...	0°·009	239°·24	0°·008	319°·34	0°·009	148°·64	0°·004	189°·31	0°·005	190°·53	0°·003	82°·31	0°·047	339°·98	0°·006	338°·13	0°·030	169°·51	0°·046	311°·78	0°·045	121°·83	Galle.
2053	47°·53	0°·016	111°·12	0°·014	117°·48	0°·003	239°·24	0°·007	340°·03	0°·009	148°·64	0°·004	189°·31	0°·005	190°·53	0°·004	14°·46	0°·058	42°·40	0°·008	338°·13	0°·036	169°·51	0°·046	311°·78	0°·045	121°·83	
2048	22°·13	0°·009	108°·73	0°·033	57°·94	0°·001	240°·24	0°·007	334°·21	0°·008	147°·42	0°·017	121°·64	0°·002	10°·46	0°·006	61°·38	0°·033	221°·67	0°·030	53°·13	0°·023	47°·40	0°·324	304°·80	0°·178	84°·63	
2050	46°·46	0°·021	82°·81	0°·044	39°·43	0°·005	243°·16	0°·018	7°·34	0°·009	49°·34	0°·016	238°·76	0°·003	5°·13	0°·007	335°·54	0°·038	42°·16	0°·012	17°·56	0°·026	213°·83	0°·280	299°·39	0°·139	138°·85	
2057	60°·27	0°·024	99°·83	0°·030	88°·62	0°·007	345°·62	0°·010	129°·12	0°·018	212°·28	0°·004	283°·46	0°·004	52°·44	0°·039	14°·27	0°·056	19°·21	0°·010	0°·00	0°·010	259°·79	0°·360	299°·20	0°·107	115°·75	
2023	36°·47	0°·020	105°·63	...	...	0°·005	258°·58	0°·008	279°·95	0°·011	56°·96	0°·031	256°·45	0°·004	154°·35	0°·005	181°·84	0°·043	18°·39	0°·033	320°·88	0°·014	35°·96	0°·338	308°·73	0°·082	118°·39	
2014	49°·84	0°·017	96°·51	0°·041	352°·06	0°·008	269°·88	0°·005	340°·03	0°·012	122°·83	0°·014	256°·15	0°·002	80°·03	0°·002	83°·42	0°·031	321°·39	0°·004	13°·97	0°·012	6°·25	0°·267	296°·88	0°·056	83°·27	
2013	76°·34	0°·026	102°·45	...	...	0°·009	269°·23	0°·008	353°·28	0°·008	153°·61	0°·003	260°·00	0°·007	67°·45	0°·005	86°·35	0°·049	23°·98	0°·009	342°·51	0°·026	274°·63	0°·313	314°·71	0°·153	121°·94	Colombo.
2013	47°·53	0°·016	111°·12	0°·014	117°·48	0°·003	239°·24	0°·007	340°·03	0°·009	148°·64	0°·004	189°·31	0°·005	190°·53	0°·004	14°·46	0°·058	42°·40	0°·008	338°·13	0°·036	169°·51	0°·046	311°·78	0°·045	121°·83	
2013	22°·13	0°·009	108°·73	0°·033	57°·94	0°·001	240°·24	0°·007	334°·21	0°·008	147°·42	0°·017	121°·64	0°·002	10°·46	0°·006	61°·38	0°·033	221°·67	0°·030	53°·13	0°·023	47°·40	0°·324	304°·80	0°·178	84°·63	
2017	11°·07	0°·004	89°·47	0°·017	35°·24	0°·002	241°·70	0°·003	0°·00	0°·004	73°·30	0°·002	60°·82	0°·001	5°·23	0°·002	335°·54	0°·018	42°·16	0°·012	17°·56	0°·026	213°·83	0°·280	299°·39	0°·139	138°·85	
2018	42°·06	0°·017	104°·30	0°·034	53°·93	0°·009	253°·20	0°·008	334°·53	0°·010	132°·59	0°·008	277°·09	0°·002	253°·16	0°·005	185°·89	0°·035	37°·06	0°·043	358°·42	0°·017	318°·50	0°·313	308°·12	0°·133	113°·46	
2048	228°·46	0°·018	131°·73	...	...	0°·019	58°·94	0°·007	160°·57	0°·027	213°·32	0°·015	72°·18	0°·012	154°·04	0°·007	331°·17	0°·081	345°·28	0°·061	34°·83	0°·084	4°·78	0°·543	230°·61	0°·400	125°·53	
2047	226°·21	0°·094	113°·94	0°·056	254°·75	0°·037	56°·69	0°·006	210°·11	0°·026	229°·56	0°·032	83°·72	0°·022	164°·11	0°·007	240°·54	0°·032	320°·44	0°·017	13°·12	0°·032	352°·68	0°·306	234°·73	0°·306	134°·13	
2045	230°·07	0°·016	142°·31	...	...	0°·006	166°·16	0°·008	198°·18	0°·035	220°·66	0°·014	68°·13	0°·011	144°·74	0°·006	314°·52	0°·078	324°·73	0°·044	64°·68	0°·023	29°·30	0°·340	234°·23	0°·300	139°·09	
2045	223°·36	0°·015	103°·32	0°·037	243°·58	0°·008	180°·11	0°·003	230°·40	0°·015	183°·27	0°·042	181°·03	0°·013	143°·81	0°·009	335°·54	0°·068	346°·87	0°·098	1°·40	0°·026	51°·18	0°·444	229°·60	0°·328	129°·04	
2050	229°·22	0°·014	104°·27	...	...	0°·004	111°·26	0°·006	302°·74	0°·020	211°·73	0°·022	153°·16	0°·020	295°·41	0°·007	330°·03	0°·048	352°·42	0°·063	351°·26	0°·043	15°·11	0°·364	225°·90	0°·377	126°·86	
2054	232°·25	0°·017	115°·09	0°·044	249°·08	0°·019	99°·26	0°·006	202°·61	0°·025	209°·30	0°·028	122°·70	0°·014	149°·28	0°·007	336°·80	0°·049	334°·63	0°·066	9°·80	0°·035	32°·36	0°·444	235°·20	0°·344	127°·64	
2053	226°·58	0°·016	136°·01	...	...	0°·004	136°·87	0°·020	228°·14	0°·064	231°·03	0°·011	81°·73	0°·011	157°·46	0°·008	76°·10	0°·049	44°·68	0°·030	4°·84	0°·081	84°·35	0°·323	200°·56	0°·275	119°·83	
2047	227°·30	0°·048	166°·21	0°·056	256°·61	0°·001	54°·27	0°·022	219°·64	0°·064	242°·30	0°·050	81°·63	0°·016	156°·23	0°·007	68°·32	0°·047	140°·30	0°·030	349°·21	0°·034	45°·62	0°·335	224°·82	0°·303	148°·07	
2047	217°·66	0°·030	163°·46	...	...	0°·023	127°·67	0°·023	234°·08	0°·069	199°·81	0°·060	155°·05	0°·008	63°·64	0°·055	68°·07	0°·053	24°·88	0°·021	44°·09	0°·049	21°·21	0°·257	114°·65	
2045	224°·36	0°·030	167°·34	0°·054	253°·34	0°·004	127°·71	0°·024	232°·71	0°·064	239°·14	0°·054	290°·68	0°·004	51°·89	0°·057	254°·23	0°·044	64°·68	0°·023	29°·30	0°·026	234°·23	0°·300	139°·09	
2045	224°·36	0°·063	194°·85	...	...	0°·043	256°·91	0°·021	256°·53	0°·061	260°·21	0°·062	76°·04	0°·003	10°·18	0°·006	14°·48	0°·017	0°·00	0°·006	83°·41	0°·026	128°·19	0°·366	225°·09	0°·363	127°·41	Madras.
2048	227°·30	0°·048	166°·21	0°·080	224°·68	0°·001	54°·27	0°·022	219°·64	0°·064	242°·30	0°·050	81°·63	0°·016	156°·23	0°·007	68°·32	0°·047	140°·30	0°·030	349°·21	0°·034	45°·62	0°·335	224°·82	0°·303	148°·07	
2048	217°·66	0°·030	163°·46	...	...	0°·023	127°·67	0°·023	234°·08	0°·069	199°·81	0°·060	155°·05	0°·008	63°·64	0°·055	68°·07	0°·053	24°·88	0°·021	44°·09	0°·049	21°·21	0°·257	114°·65	
2045	224°·36	0°·030	167°·34	0°·054	253°·34	0°·004	127°·71	0°·024	232°·71	0°·064	239°·14	0°·054	290°·68	0°·004	51°·89	0°·057	254°·23	0°·044	64°·68	0°·023	29°·30	0°·026	234°·23	0°·300	139°·09	
2045	224°·36	0°·063	194°·85	...	...	0°·043	256°·91	0°·021	256°·53	0°·061	260°·21	0°·062	76°·04	0°·003	10°·18	0°·006	14°·48	0°·017	0°·00	0°·006	83°·41	0°·026	128°·19	0°·366	225°·09	0°·363	127°·41

Table showing the comparison between the Analysed and Equilibrium theoretical values of the co-efficients of the various Tides in terms of the Main Lunar Tide M_2 for the Stations at which observations have been completed.

Station.	Year.	Semi-diurnal Tides.								Diurnal Tides.						Over Tides.						Compound Tides.						Long Period Tides.					
		Main Solar.	Luni-Solar.	Lunar Elliptic.		Evectional.	Lunar Elliptic, 2nd order.	Solar Elliptic.	Variational.	Luni-Solar.	Declinational.		Elliptic.		Lunar.			Solar.			Ter diurnal.	Quarter diurnal.	Ter diurnal.	Quarter diurnal.	Semi-diurnal.	Long Monthly.	Lunar Fortnightly.	Lunisolar Fortnightly.	Solar Annual.	Solar Semi-annual.	
		S_2	K_2	N_2	L_2	ν_2	$2N_2$	T_2	ρ_2	K_1	O_1	P_1	Q_1	J_1	M_1	S_1	M_3	M_4	M_6	M_8	S_4	S_6	S_8	$(M_2K_2)_3$	$(MS)_4$	$(2M_2K_2)_3$	$(M_2K_2)_4$	$(2SM)_2$	M_m	M_f	MS_f	S_a	S_{sa}
Equilibrium Theoretical Values		0·467	0·127	0·194	0·028	0·038	0·026	0·027	0·014	0·584	0·413	0·193	0·080	0·053	0·036		0·023						0·111	0·056	0·026	0·040		0·046	0·086	0·092			
Montague	1884-85	0·381	0·103	0·142	0·017	0·087	0·035		0·031	0·576	0·392	0·179	0·076	0·051	0·035	0·045	0·020	0·023	0·026	0·007	0·003	0·002	0·091	0·019	0·005	0·025	0·001	0·027	0·067	0·022	0·173	0·042
	1885-86	0·359	0·096	0·141	0·029	0·057	0·036	0·037	0·023	0·579	0·389	0·182	0·076	0·052	0·036	0·046	0·030	0·023	0·026	0·007	0·003	0·002	0·093	0·023	0·005	0·023	0·001	0·030	0·064	0·021	0·170	0·040
	1886-87	0·350	0·092	0·139	0·027	0·053	0·035	0·036	0·022	0·580	0·390	0·183	0·076	0·052	0·036	0·047	0·030	0·023	0·026	0·007	0·003	0·002	0·093	0·023	0·005	0·023	0·001	0·030	0·064	0·021	0·171	0·040
	1887-88	0·351	0·095	0·138	0·026	0·056	0·037	0·040	0·026	0·584	0·389	0·182	0·076	0·052	0·036	0·047	0·030	0·023	0·026	0·007	0·003	0·002	0·093	0·023	0·005	0·023	0·001	0·030	0·063	0·021	0·170	0·040
	1888-89	0·356	0·101	0·143	0·028	0·060	0·034	0·043	0·030	0·584	0·389	0·182	0·076	0·052	0·036	0·047	0·030	0·023	0·026	0·007	0·003	0·002	0·093	0·023	0·005	0·023	0·001	0·030	0·063	0·021	0·170	0·040
	Means	0·359	0·097	0·140	0·027	0·063	0·035	0·043	0·030	0·585	0·398	0·186	0·076	0·052	0·036	0·046	0·030	0·023	0·026	0·007	0·003	0·002	0·094	0·023	0·005	0·023	0·001	0·029	0·065	0·022	0·170	0·040
Galle	1884-85	0·359	0·77	0·116	0·028	0·091	0·013		0·048	0·514	0·364	0·160	0·071	0·047	0·032	0·061	0·027	0·028	0·026	0·004	0·004	0·001	0·102	0·021	0·001	0·024	0·003	0·027	0·058	0·016	0·171	0·184
	1885-86	0·359	0·77	0·116	0·028	0·091	0·013	0·036	0·048	0·514	0·363	0·160	0·071	0·047	0·032	0·061	0·027	0·028	0·026	0·004	0·004	0·001	0·102	0·021	0·001	0·024	0·003	0·027	0·058	0·016	0·171	0·184
	1886-87	0·358	0·76	0·116	0·029	0·091	0·013		0·048	0·514	0·363	0·160	0·071	0·047	0·032	0·061	0·027	0·028	0·026	0·004	0·004	0·001	0·102	0·021	0·001	0·024	0·003	0·027	0·058	0·016	0·171	0·184
	1887-88	0·358	0·76	0·116	0·029	0·091	0·013	0·036	0·048	0·514	0·363	0·160	0·071	0·047	0·032	0·061	0·027	0·028	0·026	0·004	0·004	0·001	0·102	0·021	0·001	0·024	0·003	0·027	0·058	0·016	0·171	0·184
	1888-89	0·359	0·77	0·116	0·028	0·091	0·013	0·036	0·048	0·514	0·363	0·160	0·071	0·047	0·032	0·061	0·027	0·028	0·026	0·004	0·004	0·001	0·102	0·021	0·001	0·024	0·003	0·027	0·058	0·016	0·171	0·184
	1889-90	0·358	0·76	0·114	0·028	0·090	0·013	0·036	0·048	0·514	0·363	0·160	0·071	0·047	0·032	0·061	0·027	0·028	0·026	0·004	0·004	0·001	0·102	0·021	0·001	0·024	0·003	0·027	0·058	0·016	0·171	0·184
	Means	0·357	0·76	0·115	0·027	0·091	0·016	0·036	0·048	0·514	0·363	0·160	0·071	0·047	0·032	0·061	0·027	0·028	0·026	0·004	0·004	0·001	0·102	0·021	0·001	0·024	0·003	0·027	0·058	0·016	0·171	0·184
Colombo	1884-85	0·363	0·132	0·113	0·021	0·060			0·032	0·514	0·370	0·150	0·063	0·042	0·033	0·031	0·027	0·027	0·024	0·000	0·000	0·000	0·092	0·019	0·000	0·023	0·000	0·026	0·056	0·026	0·160	0·036
	1885-86	0·363	0·185	0·089	0·031	0·065	0·021	0·073	0·030	0·510	0·379	0·110	0·048	0·031	0·023	0·027	0·025	0·025	0·022	0·000	0·000	0·000	0·084	0·014	0·000	0·021	0·000	0·023	0·044	0·016	0·142	0·030
	1886-87	0·361	0·194	0·088	0·034	0·064	0·019		0·029	0·510	0·379	0·110	0·048	0·031	0·023	0·027	0·025	0·025	0·022	0·000	0·000	0·000	0·084	0·014	0·000	0·021	0·000	0·023	0·044	0·016	0·142	0·030
	1887-88	0·361	0·194	0·088	0·034	0·064	0·019		0·029	0·510	0·379	0·110	0·048	0·031	0·023	0·027	0·025	0·025	0·022	0·000	0·000	0·000	0·084	0·014	0·000	0·021	0·000	0·023	0·044	0·016	0·142	0·030
	1888-89	0·363	0·194	0·089	0·034	0·065	0·019		0·029	0·510	0·379	0·110	0·048	0·031	0·023	0·027	0·025	0·025	0·022	0·000	0·000	0·000	0·084	0·014	0·000	0·021	0·000	0·023	0·044	0·016	0·142	0·030
	Means	0·362	0·182	0·089	0·030	0·064	0·020		0·030	0·510	0·379	0·110	0·048	0·031	0·023	0·027	0·025	0·025	0·022	0·000	0·000	0·000	0·084	0·014	0·000	0·021	0·000	0·023	0·044	0·016	0·142	0·030
Negapatam	1882-83	0·381	0·100	0·130	0·031	0·067	0·026		0·023	0·310	0·189	0·117	0·050	0·026	0·066	0·064	0·067	0·064	0·031	0·014	0·007	0·000	0·091	0·020	0·000	0·022	0·000	0·014	0·086	0·038	0·265	0·362
	1883-84	0·381	0·133	0·094	0·043	0·065	0·016	0·050	0·021	0·312	0·192	0·117	0·050	0·029	0·046	0·064	0·055	0·056	0·046	0·020	0·021	0·001	0·091	0·023	0·002	0·044	0·000	0·013	0·033	0·016	0·143	0·438
	1884-85	0·379	0·137	0·095	0·044	0·065	0·016		0·021	0·308	0·189	0·116	0·050	0·029	0·046	0·064	0·055	0·056	0·046	0·020	0·021	0·001	0·091	0·023	0·002	0·044	0·000	0·013	0·033	0·016	0·143	0·438
	1885-86	0·379	0·137	0·094	0·044	0·065	0·016		0·021	0·308	0·189	0·116	0·050	0·029	0·046	0·064	0·055	0·056	0·046	0·020	0·021	0·001	0·091	0·023	0·002	0·044	0·000	0·013	0·033	0·016	0·143	0·438
	1886-87	0·379	0·137	0·094	0·044	0·065	0·016		0·021	0·308	0·189	0·116	0·050	0·029	0·046	0·064	0·055	0·056	0·046	0·020	0·021	0·001	0·091	0·023	0·002	0·044	0·000	0·013	0·033	0·016	0·143	0·438
	Means	0·380	0·137	0·094	0·044	0·065	0·016	0·050	0·021	0·309	0·189	0·116	0·050	0·029	0·046	0·064	0·055	0·056	0·046	0·020	0·021	0·001	0·091	0·023	0·002	0·044	0·000	0·013	0·033	0·016	0·143	0·438
Madras	1882-83	0·417	0·116	0·133	0·033	0·081	0·061		0·044	0·587	0·390	0·189	0·094	0·058	0·018	0·035	0·044	0·041	0·020	0·001	0·002	0·001	0·101	0·024	0·006	0·026	0·000	0·031	0·068	0·026	0·195	0·263
	1883-84	0·417	0·116	0·133	0·033	0·081	0·061	0·053	0·044	0·587	0·390	0·189	0·094	0·058	0·018	0·035	0·044	0·041	0·020	0·001	0·002	0·001	0·101	0·024	0·006	0·026	0·000	0·031	0·068	0·026	0·195	0·263
	1884-85	0·419	0·126	0·127	0·051	0·069	0·052		0·039	0·579	0·398	0·198	0·090	0·054	0·011	0·026	0·035	0·039	0·021	0·003	0·003	0·001	0·101	0·024	0·008	0·028	0·000	0·031	0·072	0·026	0·196	0·245
	1885-86	0·419	0·126	0·127	0·051	0·069	0·052	0·078	0·039	0·579	0·398	0·198	0·090	0·054	0·011	0·026	0·035	0·039	0·021	0·003	0·003	0·001	0·101	0·024	0·008	0·028	0·000	0·031	0·072	0·026	0·196	0·245
	1886-87	0·421	0·126	0·130	0·051	0·070	0·060		0·040	0·580	0·398	0·198	0·090	0·054	0·011	0·026	0·035	0·039	0·021	0·003	0·003	0·001	0·101	0·024	0·008	0·028	0·000	0·031	0·072	0·026	0·196	0·245
	1887-88	0·421	0·126	0·130	0·051	0·070	0·060	0·078	0·040	0·580	0·398	0·198	0·090	0·054	0·011	0·026	0·035	0·039	0·021	0·003	0·003	0·001	0·101	0·024	0·008	0·028	0·000	0·031	0·072	0·026	0·196	0·245
	1888-89	0·421	0·126	0·130	0·051	0·070	0·060	0·078	0·040	0·580	0·398	0·198	0·090	0·054	0·011	0·026	0·035	0·039	0·021	0·003	0·003	0·001	0·101	0·024	0·008	0·028	0·000	0·031	0·072	0·026	0·196	0·245
	Means	0·419	0·123	0·129	0·050	0·071	0·059	0·078	0·040	0·582	0·396	0·196	0·090	0·054	0·013	0·030	0·039	0·040	0·021	0·003	0·003	0·001	0·101	0·024	0·008	0·028	0·000	0·031	0·072	0·026	0·196	0·245
Cocanada	1886-87	0·433	0·118	0·107	0·031	0·096	0·029		0·013	0·534	0·390	0·167	0·071	0·049	0·013	0·034	0·014	0·017	0·009	0·001	0·002	0·001	0·102	0·021	0·002	0·023	0·000	0·027	0·061	0·023	0·174	0·171
	1887-88	0·433	0·118	0·107	0·031	0·096	0·029	0·041	0·013	0·534	0·390	0·167	0·071	0·049	0·013	0·034	0·014	0·017	0·009	0·001	0·002	0·001	0·102	0·021	0·002	0·023	0·000	0·027	0·061	0·023	0·174	0·171
	1888-89	0·431	0·118	0·106	0·043	0·095	0·029	0·041	0·013	0·534	0·390	0·167	0·071	0·049	0·013	0·034	0·014	0·017	0·011	0·001	0·002	0·001	0·102	0·021	0·002	0·023	0·000	0·027	0·061	0·023	0·174	0·171
	1889-90	0·431	0·118	0·106	0·043	0·095	0·029	0·041	0·013	0·534	0·390	0·167	0·071	0·049	0·013	0·034	0·014	0·017	0·011	0·001	0·002	0·001	0·102	0·021	0·002	0·023	0·000	0·027	0·061	0·023	0·174	0·171
	1890-91	0·427	0·119	0·111	0·043	0·094	0·030	0·038	0·016	0·534	0·390	0·167	0·071	0·049	0·013	0·034	0·014	0·017	0·011	0·001	0·002	0·001	0·102	0·021	0·002	0·023	0·000	0·027	0·061	0·023	0·174	0·171
	Means	0·432	0·118	0·107	0·034	0·095	0·029	0·040	0·014	0·534	0·390	0·167	0·071	0·049	0·013	0·034	0·014	0·017	0·010	0·001	0·002	0·001	0·102	0·021	0·002	0·023	0·000	0·027	0·061	0·023	0·174	0·171
Chittagong	1881-82	0·384	0·099	0·136	0·036	0·091	0·047		0·061	0·539	0·483	0·243	0·104	0·072	0·014	0·049	0·055	0·058	0·028	0·011	0·010	0·000	0·136	0·280	0·011	0·038	0·009	0·017	0·041	0·058	0·376	0·040
	1882-83	0·384	0·099	0·136	0·036	0·091	0·047	0·051	0·061	0·539	0·483	0·243	0·104	0·072	0·014	0·049	0·055	0·058	0·028	0·011	0·010	0·000	0·136	0·280	0·011	0·038	0·009	0·017	0·041	0·058	0·376	0·040
	1881-89	0·386	0·080	0·151	0·036	0·096	0·048	0·050	0·065	0·539	0·483	0·243	0·104	0·072	0·014	0·049	0·055	0·058	0·028	0·011	0·010	0·000	0·136	0·280	0·011	0·038	0·009	0·017	0·041	0·058	0·376	0·040
	1889-90	0·386	0·080	0·151	0·036	0·096	0·048	0·050	0·065	0·539	0·483	0·243	0·104	0·072	0·014	0·049	0·055	0·058	0·028	0·011	0·010	0·000	0·136	0·280	0·011	0·038	0·009	0·017	0·041	0·058	0·376	0·040
	Means	0·385	0·089	0·144	0·036	0·094	0·048	0·050	0·064	0·539	0·483	0·243	0·104	0·072	0·014	0·049	0·055	0·058	0·028	0·011	0·010	0·000	0·136	0·280	0·011	0·038	0·009	0·017	0·041	0·058	0·376	0·040
Elephant Point	1884	0·406	0·187	0·084	0·053	0·092	0·046	0·059	0·035	0·579	0·408	0·206	0·097	0·065	0·027	0·054	0·048	0·043	0·016	0·006	0·002	0·000	0·102	0·023	0·002	0·026	0·000	0·030	0·076	0·038	0·138	0·093
	1885	0·407	0·191	0·079	0·042	0·093	0·035	0·054	0·026	0·615	0·434	0·219	0·102	0·069	0·011	0·052	0·064	0·049	0·041	0·017	0·003	0·001	0·099	0·030	0·003	0·034	0·000	0·031	0·073	0·042	0·148	0·088
	1886	0·407	0·191	0·079	0·042	0·093	0·035		0·026	0·615	0·434	0·219	0·102	0·069	0·011	0·052	0·064	0·049	0·041	0·017	0·003	0·001	0·099	0·030	0·003	0·034	0·000	0·031	0·073	0·042	0·148	0·088
	1887	0·406	0·190	0·104	0·036	0·091	0·047		0·026	0·615	0·434	0·219	0·102	0·069	0·011	0·052	0·064	0·049	0·041	0·017	0·003	0·001	0·099	0·030	0·003	0·034	0·000	0·031	0·073	0·042	0·149	0·088
	1888-89	0·406	0·190	0·104	0·036	0·091	0·047		0·026	0·615	0·434	0·219	0·102	0·069	0·011	0·052	0·064	0·049	0·041	0·017	0·003	0·001	0·099	0·030	0·003	0·034	0·000	0·031	0·073	0·042	0·149	0·088
	Means	0·406	0·191	0·088	0·042	0·092	0·044	0·059	0·026	0·616	0·434	0·219	0·102	0·069	0·011	0·052	0·064	0·049	0·041	0·017	0·003	0·001	0·099	0·030	0·003	0·034	0·000	0·031	0·073	0·042	0·148	0·088

An inspection of the observatory, lasting from the 15th to the 21st May, was made by Mr. Belcham, who found that the tide gauge and aneroid were in adjustment and working well, but much in need of cleaning. He had the several instruments thoroughly cleaned, and after setting up a new anemometer, which he took with him, brought away the damaged instrument for repair. During the inspection the observatory was frequently visited by Colonel Cadell, V.C., the Chief Commissioner of the Andamans, who directed the Sub-Engineer to include it in his rounds of inspection, and to see that the communication holes in the cylinder were kept open so as to ensure a correct record of the tides.

If the unfortunate discontinuance of tidal registrations at Madras, and the disappointing nature of the recent tidal observations at Aden, be excepted, I think we are entitled to congratulate ourselves on the results obtained at the various tidal stations during the year under report. It is specially satisfactory to note the great, and it is to be hoped permanent, improvement which has taken place at Port Blair, to which, being a permanent ocean station, we look for data which ought to prove of great general interest and utility.

Reduction of the Tidal Observations.

The observations at 15 tidal stations have been reduced, and two years' calculations having been made in the case of three of them, the total calculations are thus equivalent to the reduction of 18 years' observations at one station. The tabulated values of the tidal constants so obtained are appended.

Two other tables marked No. 1 and No. 2, giving the results of the tidal registrations at eight stations closed since the General Report 1886-87 was submitted, are also appended. Table No. 1 gives the actual values in feet and degrees of the mean amplitudes and epochs of the tidal components, and Table No. 2 their values in terms of the main lunar tide M_2 for comparison with the equilibrium theoretical values. Similar tables were published in the above-mentioned General Report for the stations closed up to the 30th September 1887.

It was mentioned in the General Report for 1887-88 that a commencement had been made tentatively towards utilising the meteorological records of the tidal observations for tidal purposes, three years observations at Karwar having been selected for treatment; and Mr. Roberts of the Nautical Almanac Office was requested to run off, by means of the tide predicting machine at the India Office, certain constituent tides required in the investigation. Nothing, however, has as yet been heard from him on the subject, and the investigation must be postponed until we receive the curves applied for.

The present state of the ordinary tidal computations is shown in the table following, together with their state at the end of September 1890. The letters A. P. in the table indicate that the actual times and heights of high and low water have been measured in duplicate from the tidal diagrams and compared with their predicted values published in the tide tables. The actual amount of work done during the year under report can thus be seen at a glance.

The extra tidal work is not entered in the table. This consisted in furnishing the Calcutta Municipal Corporation with the actual time and height of every high and low water at Kidderpore, for the 15 months, extending from 1st August 1889 to 30th November 1890, for use in connection with the important works contemplated for the improvement and extension of the drainage of Calcutta, and in submitting reports as before, on the tidal operations carried on in the Bombay Presidency and in Burma, to the Local Governments.

In the annual report of this party submitted last year I find it stated under the heading 'Reduction of the tidal observations' that "every endeavour was made to clear off as much of the arrears as possible." With reference to this I would remark that, while every endeavour has always been made by Mr. Connor and his computers to reduce the observations of each tidal observatory as soon as possible after the completion of each year of observation, the reductions take time; and it frequently happens that in an annual report recording the completion of a year's observations at an observatory, the completion of their reduction cannot at the same time be announced. Such unfinished calculations cannot properly be termed arrears. When I went on furlough in 1888 the reductions were not in arrear, and I find that no arrears have accumulated since then under any of the three officers who held charge of this party during my absence.

State of the ordinary reductions of the yearly tidal-registrations at the beginning and end of the Survey year 1890-91.

Tidal Observatory.	State at end of September 1890.	State at end of September 1891.
Aden . .	1888-89, calculations completed. 1889-90, diagrams read off. A. P.	1889-90, calculations completed. 1890-91, observations rejected in part. A. P. 1890.
Kurrachee . .	1887-88, calculations completed. 1888-89, calculations completed. 1889-90, diagrams read off. A. P.	1889-90, calculations completed. 1890-91, calculations completed. A. P. 1890.

State of the ordinary reductions of the yearly tidal-registrations at the beginning and end of the Survey year 1890-91—continued.

Tidal Observatory.	State at end of September 1890.	State at end of September 1891.
Bhávnagar .	1889, calculations completed. A. P.	1890, calculations completed. A. P. 1890.
Bombay (Apollo Bandar.)	1889, calculations completed. A. P.	1890, calculations completed. A. P. 1890.
Bombay (Prince's Dock)	1888-89, calculations completed. 1889, calculations completed. A. P.	1890, calculations completed. A. P. 1890.
Cochin	1889-90, calculations completed. A. P.	1890-91, calculations completed. A. P. 1890.
Minicoy (started 12th January 1891).	.....	Newly started observatory.
Colombo (closed 29th March 1890).	1889-90, calculations completed. A. P.	A. P. 1890.
Galle (closed 11th April 1890).	1888-89, calculations completed. 1889-90, calculations completed. A. P.	A. P. 1890.
Trincomalee (started 10th November 1890).	.....	Newly started observatory.
Tuticorin . .	1889-90, calculations completed.	1890-91, calculations completed. A. P. 1890.
Madras (closed 10th October 1890).	1888-89, calculations completed. A. P.	1889-90, calculations completed. A. P. 1890.
Cocanada (closed 18th April 1891).	1889-90, calculations completed. A. P.	1890-91, calculations completed. A. P. 1890.
Kidderpore . .	1888-89, calculations completed. A. P.	1889-90, calculations completed. 1890-91, calculations completed.
Chittagong (closed 22nd July 1891).	1889-90, calculations completed. A. P.	1890-91, calculations completed. A. P. 1890.
Akyab . . .	1889-90, calculations completed. A. P.	1890-91, calculations completed. A. P. 1890.
Rangoon . . .	1888-89, calculations completed. A. P.	1889-90, calculations completed. 1890-91, calculations completed. A. P. 1890.
Mergui . .	1889-90, calculations completed.	1890-91, calculations completed.
Port Blair . .	1888-89, calculations completed. 1889-90, calculations completed. A. P.	1890-91, calculations completed. A. P. 1890.

Values of the Tidal Constants, Aden, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Aden; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

$A_0 = 5{\cdot}835$ feet.

S_1	H = R =	·101	M_6 R =	·002	Q_1 R =	·145	T_2 R =	·067
	$\kappa = \zeta =$	173°·08	ζ =	36°·03	ζ =	52°·42	ζ =	283°·19
S_2	H = R =	·682	H =	·002	H =	·145	H =	·067
	$\kappa = \zeta =$	243°·39	κ =	300°·79	κ =	39°·91	κ =	222°·90
S_4	H = R =	·002	M_8 R =	·004	L_2 R =	·031	$(MS)_3$ R =	·014
	$\kappa = \zeta =$	281°·31	ζ =	178°·26	ζ =	341°·27	ζ =	180°·87
S_6	H = R =	·008	H =	·004	H =	·025	H =	·014
	$\kappa = \zeta =$	201°·40	κ =	51°·28	κ =	228°·88	κ =	149°·12
S_8	H = R =	·001	O_1 R =	·650	N_2 R =	·428	$(2SM)_2$ R =	·026
	$\kappa = \zeta =$	323°·13	ζ =	305°·43	ζ =	353°·36	ζ =	60°·40
			H =	·654	H =	·426	H =	·025
			κ =	35°·36	κ =	219°·17	κ =	92°·14

Short Period Tides—contd.

A_0=5·835 feet.

M_1	R =	·035	K_1	R =	1·307	λ_2	R =	...	$2N_2$	R =	·096
	ζ =	118°·26		ζ =	151°·20		ζ =	...		ζ =	73°·89
	H =	·034		H =	1·311		H =	...		H =	·095
	κ =	267°·29		κ =	33°·63		κ =	...		κ =	197°·27
M_2	R =	1·576	K_2	R =	·200	ν_2	R =	·129	$(M_2N)_4$	R =	·057
	ζ =	255°·33		ζ =	293°·66		ζ =	151°·51		ζ =	220°·96
	H =	1·566		H =	·206		H =	·128		H =	·056
	κ =	223°·58		κ =	238°·53		κ =	192°·56		κ =	55°·03
M_3	R =	·019	P_1	R =	·413	μ_2	R =	·102	$(M_2K_1)_3$	R =	·009
	ζ =	229°·10		ζ =	281°·28		ζ =	240°·61		ζ =	287°·59
	H =	·019		H =	·413		H =	·101		H =	·009
	κ =	181°·48		κ =	2,°·95		κ =	177°·12		κ =	138°·27
M_4	R =	·004	J_1	R =	·084	R_2	R =	...	$(2M_2K_1)_3$	R =	·012
	ζ =	11°·89		ζ =	70°·05		ζ =	...		ζ =	311°·88
	H =	·004		H =	·083		H =	...		H =	·012
	κ =	308°·40		κ =	50°·81		κ =	...		κ =	5°·96

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·030	252°·30	·029	354°·74
„ Fortnightly „ . . .	·042	44·06	·043	12·45
Luni-Solar „ „ . . .	·024	191·21	024	222·95
Solar-Annual „ . . .	·381	14·44	·381	255·76
„ Semi-Annual „ . . .	·083	155·30	·083	117·96

Values of the Tidal Constants, Kurrachee, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Kurrachee; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 7·143 feet

S_1	H = R =	·095	M_6	R =	·042	Q_1	R =	·156	T_2	R =	·053
	κ = ζ =	165°·17		ζ =	346°·92		ζ =	160°·38		ζ =	163°·13
S_2	H = R =	·946		H =	·043		H =	·147		H =	·053
	κ = ζ =	324°·44		κ =	202°·93		κ =	53°·85		κ =	45°·01
S_4	H = R =	·010	M_8	R =	·006	L_2	R =	·092	$(MS)_4$	R =	·032
	κ = ζ =	42°·94		ζ =	294°·94		ζ =	159°·44		ζ =	272°·41
S_6	H = R =	·007		H =	·006		H =	·089		H =	·033
	κ = ζ =	302°·99		κ =	222°·97		κ =	308°·40		κ =	344°·42
S_8	H = R =	·002	O_1	R =	·700	N_2	R =	·616	$(2SM)_2$	R =	·023
	κ = ζ =	25°·02		ζ =	270°·85		ζ =	88°·87		ζ =	183°·22
				H =	·658		H =	·622		H =	·024
				κ =	45°·53		κ =	279°·68		κ =	111°·22
M_1	R =	·111	K_1	R =	1·364	λ_2	R =	...	$2N_2$	R =	·097
	ζ =	320°·14		ζ =	105°·17		ζ =	...		ζ =	321°·50
	H =	·069		H =	1·311		H =	...		H =	·098
	κ =	55°·96		κ =	46°·09		κ =	...		κ =	271°·11
M_2	R =	2·558	K_2	R =	·301	ν_2	R =	·204	$(M_2N)_4$	R =	·069
	ζ =	221°·90		ζ =	263°·73		ζ =	235°·62		ζ =	213°·91
	H =	2·580		H =	·277		H =	·206		H =	·070
	κ =	293°·91		κ =	325°·14		κ =	262°·91		κ =	116°·72
M_3	R =	·034	P_1	R =	·371	μ_2	R =	·059	$(M_2K_1)_3$	R =	·068
	ζ =	35°·20		ζ =	355°·36		ζ =	118°·10		ζ =	45°·19
	H =	·035		H =	·371		H =	·060		H =	·065
	κ =	323°·27		κ =	46°·18		κ =	262°·11		κ =	58°·11
M_4	R =	·037	J_1	R =	·106	R_2	R =	...	$(2M_2K_1)_3$	R =	·028
	ζ =	210°·94		ζ =	226°·57		ζ =	...		ζ =	194°·60
	H =	·038		H =	·100		H =	...		H =	·027
	κ =	354°·95		κ =	45°·10		κ =	...		κ =	37°·70

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·071	27°·01	·073	268°·21
„ Fortnightly „ . . .	·014	37·40	·012	20·06
Luni-Solar „ „ . . .	·023	111·55	·023	39 54
Solar-Annual „ . . .	·171	43·58	·171	82·76
„ Semi Annual „ . . .	·227	85·89	·227	164 25

VALUES OF THE TIDAL CONSTANTS, KURRACHEE, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Kurrachee; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations :—

Short Period Tides.

A_0=7·155 feet.

S_1	H=R=	·087	M_6	R=	·046	Q_1	R=	·131	T_2	R=	·048
	κ=ζ=	180°·66		ζ=	284°·27		ζ=	173°·22		ζ=	32°·44
S_2	H=R=	·963		H=	·046		H=	·130		H=	·048
	κ=ζ=	323°·61		κ=	197°·91		κ=	55°·48		κ=	274°·06
S_4	H=R=	·013	M_8	R=	·001	L_2	R=	·108	$(MS)_4$	R=	·048
	κ=ζ=	24°·96		ζ=	150°·26		ζ=	344°·51		ζ=	2°·26
S_6	H=R=	·006		H=	·001		H=	·088		H=	·048
	κ=ζ=	308° 05		κ=	35°·10		κ=	287°·77		κ=	333°·47
S_8	H=R=	·001	O_1	R=	·660	N_2	R=	·615	$(2SM)_2$	R=	·026
	κ=ζ=	341°·57		ζ=	10°·92		ζ=	99°·47		ζ=	96°·71
				H=	·657		H=	·613		H=	·026
				κ=	45°·67		κ=	278°·20		κ=	125°·50
M_1	R=	·011	K_1	R=	1°·306	λ_2	R=	...	$2N_2$	R=	·110
	ζ=	231°·51		ζ=	106°·09		ζ=	...		ζ=	206° 97
	H=	·011		H=	1·302		H=	...		H=	·109
	κ=	35°·01		κ=	46°·62		κ=	...		κ=	233°·22
M_2	R=	2·564	K_2	R=	·255	ν_2	R=	·208	$(M_2N)_4$	R=	·100
	ζ=	322° 72		ζ=	258°·76		ζ=	204°·97		ζ=	258°·67
	H=	2·554		H=	·258		H=	·207		H=	·099
	κ=	293° 9		κ=	319°·77		κ=	301°·99		κ=	48°·61
M_3	R=	·045	P_1	R=	·402	μ_2	R=	·079	$(M_2K_1)_3$	R=	·046
	ζ=	2°·38		ζ=	355°·83		ζ=	339°·42		ζ=	110°·21
	H=	·044		H=	·402		H=	·078		H=	·046
	κ=	319°·19		κ=	46°·41		κ=	281°·84		κ=	21°·96
M_4	R=	·033	J_1	R=	·058	R_2	R=	...	$(2M_2K_1)_3$	R=	·023
	ζ=	59°·56		ζ=	334° 28		ζ=	...		ζ=	44°·63
	H=	033		H=	·057		H=	...		H=	·023
	κ=	1°·99		κ=	63°·23		κ=	...		κ=	46°·52

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·061	133°·89	·060	286°·36
„ Fortnightly „ . . .	039	253·43	·039	335·16
Luni-Solar „ „ . . .	·029	185·78	·029	214·57
Solar-Annual „ . . .	·087	16·42	·087	55·84
„ Semi-Annual „ . . .	·177	90 91	·177	169·76

Values of the Tidal Constants, Bhavnagar, 1890.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890 observations at Bhavnagar; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890 observations :—

Short Period Tides.

A_0=22·742 feet.

S_1	H =	·158	M_6	R =	·228	Q_1	R =	·179	T_2	R =	·035
	κ = ζ =	182°·11		ζ =	125°·44		ζ =	269°·74		ζ =	79°·46
S_2	H = R =	3·482		H =	231		H =	·172		H =	·035
	κ = ζ =	176°·30		κ =	119°·74		κ =	96°·09		κ =	79°·63
S_4	H = R =	·107	M_8	R =	·014	L_2	R =	·682	$(MS)_4$	R =	·636
	κ = ζ =	236°·28		ζ =	208°·96		ζ =	89°·62		ζ =	73°·97
S_6	H = R =	·019		H =	·015		h =	·593		H =	·639
	κ = ζ =	310°·93		κ =	321°·35		κ =	152°·05		κ =	192°·07
S_8	H = R =	·005	O_1	R =	1·016	N_2	R =	2·335	$(2SM)_2$	R =	·091
	κ = ζ =	38°·66		ζ =	143°·76		ζ =	108°·82		ζ =	124°·84
				H =	·972		H =	2·346		H =	·092
				κ =	83°·31		κ =	113°·71		κ =	6°·74
M_1	R =	·051	K_1	R =	2·375	λ_2	R =	…	$2N_2$	R =	·423
	ζ =	177°·08		ζ =	268°·36		ζ =	…		ζ =	205°·30
	H =	039		H =	2·309		H =	…		H =	·424
	κ =	281°·47		κ =	90°·68		κ =	…		κ =	96°·98
M_2	R =	10·845	K_2	R =	·761	ν_2	R =	·435	$(M_2N)_4$	R =	·213
	ζ =	15°·39		ζ =	348°·38		ζ =	148°·93		ζ =	319°·14
	H =	10·894		H =	·723		H =	·437		H =	·215
	κ =	133°·49		κ =	172°·70		κ =	140°·46		κ =	82°·13
M_3	R =	·071	P_1	R =	·679	μ_2	R =	·376	$(M_2K_1)_3$	R =	·186
	ζ =	305°·19		ζ =	286°·56		ζ =	23°·36		ζ =	134°·44
	H =	·071		H =	·679		H =	·379		H =	·182
	κ =	302°·34		κ =	95°·67		κ =	259°·55		κ =	74°·86
M_4	R =	·820	J_1	R =	·173	R_2	R =	…	$(2M_2K_1)_3$	R =	·154
	ζ =	272°·062		ζ =	235°·13		ζ =	…		ζ =	296°·65
	H =	·828		H =	·165		H =	…		H =	·151
	κ =	148°·82		κ =	166°·89		κ =	…		κ =	350°·52

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·083	187°·64	·084	300°·85
„ Fortnightly „ . . .	·076	234·95	·069	293·94
Luni-Solar „ . . .	·137	162·30	·138	44·21
Solar-Annual „ . . .	·215	167·02	·215	87·91
„ Semi-Annual „ . . .	·234	4·87	·234	206·65

Values of the Tidal Constants, Bombay (Apollo Bandar), 1890.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890 observations at Bombay (Apollo Bandar); and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890 observations :—

Short Period Tides.

A_0 = 10·230 feet.

S_1	H = R =	·073	M_6	R =	·006	Q_1	R =	·133	T_2	R =	·057
	κ = ζ =	201°·51		ζ =	52°·50		ζ =	225°·40		ζ =	350°·67
S_2	H = R =	1·581		H =	·006		H =	·127		H =	·057
	κ = ζ =	6°·16		κ =	46°·93		κ =	51°·82		κ =	350°·84
S_4	H = R =	·018	M_8	R =	·001	L_2	R =	·156	$(MS)_4$	R =	·158
	κ = ζ =	180°·96		ζ =	56°·31		ζ =	258°·80		ζ =	280°·95
S_6	H = R =	·003		H =	·001		H =	·136		H =	·158
	κ = ζ =	222°·27		κ =	168°·89		κ =	321°·26		κ =	39°·10
S_8	H = R =	·002	O_1	R =	·696	N_2	R =	·972	$(2SM)_2$	R =	·034
	κ = ζ =	166°·76		ζ =	108°·45		ζ =	312°·18		ζ =	233°·97
				H =	·666		H =	·976		H =	·035
				κ =	48°·06		κ =	317°·14		κ =	115°·83

Short Period Tides—contd.

A_0=10·230 feet.

M_1	R =	·039	K_1	R =	1·441	λ_2	R =	...	$2N_2$	R =	·159
	ζ =	230°·33		ζ =	223°·45		ζ =	...		ζ =	21°·01
	H =	·029		H =	1·402		H =	...		H =	·160
	κ =	334°·75		κ =	45°·77		κ =	...		κ =	272°·79
M_2	R =	4·009	K_2	R =	·403	ν_2	R =	·144	$(M_2N)_4$	R =	·093
	ζ =	213°·71		ζ =	174°·24		ζ =	14°·11		ζ =	184°·42
	H =	4·027		H =	·383		H =	·145		H =	·093
	κ =	331°·85		κ =	358°·55		κ =	5°·72		κ =	307°·53
M_3	R =	·056	P_1	R =	·403	μ_2	R =	·187	$(M_2K_1)_3$	R =	·093
	ζ =	27°·18		ζ =	236°·48		ζ =	84°·30		ζ =	226°·97
	H =	·056		H =	·409		H =	·189		H =	·091
	κ =	24°·40		κ =	45° 59		κ =	320°·59		κ =	167°·44
M_4	R =	·144	J_1	R =	·070	R_2	R =	...	$(2M_2K_1)_3$	R =	·073
	ζ =	96°·19		ζ =	145°·45		ζ =	...		ζ =	38°·84
	H =	·145		H =	·067		H =	...		H =	·072
	κ =	332° 48		κ =	77°·17		κ =	..		κ =	92°·81

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·086	149° 79	·088	262°·98
„ Fortnightly „	·019	318·88	·017	17 82
Luni-Solar „ „	·012	96·92	·012	338 77
Solar-Annual „	·086	77·73	·086	358·62
„ Semi-Annual „	·244	7·78	·244	209·56

Values of the Tidal Constants, Bombay (Prince's Dock), 1890.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890 observations at Bombay (Prince's Dock); and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890 observations:—

Short Period Tides.

A_0 = 8·290 feet.

S_1	H=R =	·686	M_6	R =	·007	Q_1	R =	·129	T_2	R =	·051
	κ = ζ =	204° 20		ζ =	217° 04		ζ =	226°·89		ζ =	339°·48
S_2	H=R =	1·640		H =	·007		H =	·124		H =	·051
	κ = ζ =	3°·99		κ =	211°·48		κ =	53°·31		κ =	339°·65
S_4	H= R =	·030	M_8	R =	·004	L_2	R =	·170	$(MS)_4$	R =	·137
	κ = ζ =	202°·87		ζ =	332°·59		ζ =	264°·10		ζ =	277°·12
S_6	H=R =	·003		H =	·004		H =	·148		H =	·138
	κ = ζ =	206°·57		κ =	85°·18		κ =	326°·56		κ =	35°·27
S_8	H=R =	·002	O_1	R =	·681	N_2	R =	·982	$(2SM)_2$	R =	·039
	κ = ζ =	262°·57		ζ =	107°·69		ζ =	309°·36		ζ =	240°·92
				H =	·651		H =	·986		H =	·039
				κ =	47°·29		κ =	314°·32		κ =	122°·77
M_1	R =	·044	K_1	R =	1·437	λ_2	R =	...	$2N_2$	R =	·163
	ζ =	215°·13		ζ =	222°·45		ζ =	...		ζ =	14°·80
	H =	·033		H =	1·397		H =	...		H =	·164
	κ =	319°·55		κ =	44°·77		κ =	...		κ =	266°·58
M_2	R =	4·084	K_2	R =	·409	ν_2	R =	·147	$(M_2N)_4$	R =	·092
	ζ =	211°·48		ζ =	173°·69		ζ =	10°·31		ζ =	179°·87
	H =	4·102		H =	·388		H =	·148		H =	·092
	κ =	329°·62		κ =	358°·01		κ =	1°·91		κ =	302°·98
M_3	R =	·061	P_1	R =	·411	μ_2	R =	·190	$(M_2K_1)_3$	R =	·088
	ζ =	29°·11		ζ =	234°·77		ζ =	82°·75		ζ =	236°·00
	H =	·061		H =	·411		H =	·192		H =	·086
	κ =	26°·33		κ =	43°·88		κ =	319°·05		κ =	176°·46
M_4	R =	·133	J_1	R =	·066	R_2	R =	...	$(2M_2K_1)_3$	R =	·069
	ζ =	84°·52		ζ =	146°·48		ζ =	...		ζ =	30°·86
	H =	·134		H =	·063		H =	...		H =	·067
	κ =	320°·81		κ =	78°·21		κ =	...		κ =	84°·83

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·078	152°·17	·079	265°·35
„ Fortnightly „ . . .	·025	311·24	·023	10·18
Luni-Solar „ „ . . .	·030	145·35	·030	27·21
Solar-Annual „ . . .	·083	58·32	·083	339·21
„ Semi-Annual „ . . .	·239	7·18	·239	208·96

Values of the Tidal Constants, Cochin, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Cochin; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 2·345 feet.

S_1	H = R =	·026	M_6	R =	·008	Q_1	R =	·072	T_2	R =	·039
	κ = ζ =	186°·19		ζ =	43°·86		ζ =	85°·52		ζ =	70°·72
S_2	H = R =	·260		H =	·008		H =	·069		H =	·039
	κ = ζ =	28°·42		κ =	83°·54		κ =	69°·85		κ =	47°·25
S_4	H = R =	·004	M_8	R =	·004	L_2	R =	·022	$(MS)_4$	R =	·023
	κ = ζ =	188°·13		ζ =	12°·72		ζ =	209°·78		ζ =	256°·03
S_6	H = R =	·005		H =	·004		H =	·019		H =	·023
	κ = ζ =	250°·77		κ =	305°·64		κ =	1°·79		κ =	149°·26
S_8	H = R =	·002	O_1	R =	·313	N_2	R =	·146	$(2SM)_2$	R =	·005
	κ = ζ =	277°·43		ζ =	8°·68		ζ =	116°·92		ζ =	226°·79
				H =	·298		H =	·147		H =	·005
				κ =	59°·63		κ =	303°·53		κ =	333°·56
M_1	R =	·033	K_1	R =	·598	λ_2	R =	...	$2N_2$	R =	·021
	ζ =	181°·03		ζ =	206°·22		ζ =	...		ζ =	148°·08
	H =	·024		H =	·580		H =	...		H =	·021
	κ =	356°·30		κ =	52°·24		κ =	...		κ =	268°·07
M_2	R =	·716	K_2	R =	·088	υ_2	R =	0·16	$(M_2N)_4$	R =	·023
	ζ =	80°·04		ζ =	152°·29		ζ =	155°·03		ζ =	45°·56
	H =	·720		H =	·083		H =	·016		H =	·023
	κ =	333°·27		κ =	23°·98		κ =	10°·22		κ =	125°·40
M_3	R =	·016	P_1	R =	·163	μ_2	R =	·008	$(M_2K_1)_3$	R =	·039
	ζ =	6°·71		ζ =	267°·85		ζ =	13°·69		ζ =	41°·50
	H =	·016		H =	·163		H =	·008		H =	·038
	κ =	206°·55		κ =	53°·31		κ =	160°·15		κ =	140°·75
M_4	R =	·027	J_1	R =	·032	R_2	R =	...	$(2M_2K_1)_3$	R =	·018
	ζ =	293°·87		ζ =	171°·82		ζ =	...		ζ =	170°·11
	H =	·027		H =	·031		H =	...		H =	·018
	κ =	80°·33		κ =	80°·72		κ =	...		κ =	110°·54

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·053	163°·06	·054	229°·68
„ Fortnightly „ . . .	·028	60·49	·025	31·82
Luni-Solar „ „ . . .	·015	31·34	·015	138·11
Solar-Annual „ . . .	·352	354·92	·352	299·46
„ Semi-Annual „ . . .	·109	304·34	·109	193·41

Values of the Tidal Constants, Tuticorin, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Tuticorin; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

$A_0 = 2{\cdot}119$ feet.

S_1	H = R =	·057	M_6	R =	·014	Q_1	R =	·042	T_2	R =	·008
	κ = ζ =	59°·38		ζ =	345°·42		ζ =	328°·83		ζ =	322°·70
S_2	H = R =	·478		H =	·015		H =	·039		H =	·008
	κ = ζ =	82°·70		κ =	23°·14		κ =	73°·54		κ =	173°·07
S_4	H = R =	·005	M_8	R =	·006	L_2	R =	·031	$(MS)_4$	R =	·011
	κ = ζ =	232°·70		ζ =	195°·46		ζ =	290°·36		ζ =	248°·39
S_6	H = R =	·007		H =	·006		H =	·032		H =	·012
	κ = ζ =	201°·16		κ =	245°·76		κ =	78°·48		κ =	260°·97
S_8	H = R =	·014	O_1	R =	·127	N_2	R =	·085	$(2SM)_2$	R =	·009
	κ = ζ =	227°·92		ζ =	2°·58		ζ =	319°·51		ζ =	327°·58
				H =	·119		H =	085		H =	·009
				κ =	46°·17		κ =	33°·21		κ =	315°·01
M_1	R =	·028	K_1	R =	·313	λ_2	R =	...	$2N_2$	R =	·020
	ζ =	329°·98		ζ =	55°·32		ζ =	...		ζ =	268°·58
	H =	·017		H =	·300		H =	...		H =	·021
	κ =	39°·21		κ =	27°·85		κ =	...		κ =	43°·41
M_2	R =	·660	K_2	R =	·135	ν_2	R =	·031	$(M_2N)_4$	R =	·014
	ζ =	30°·13		ζ =	316°·49		ζ =	58°·75		ζ =	5°·36
	H =	·666		H =	·123		H =	·031		H =	·014
	κ =	42°·71		κ =	81°·09		κ =	24°·83		κ =	91°·63
M_3	R =	·022	P_1	R =	·078	μ_2	R =	·025	$(M_2K_1)_3$	R =	·002
	ζ =	320°·79		ζ =	344°·00		ζ =	67°·72		ζ =	279°·87
	H =	·022		H =	·078		H =	·025		H =	·002
	κ =	159°·65		κ =	3°·31		κ =	92°·87		κ =	264°·97
M_4	R =	·024	J_1	R =	·022	R_2	R =	...:	$(2M_2K_1)_3$	R =	·007
	ζ =	130°·00		ζ =	124°·40		ζ =	...		ζ =	244°·61
	H =	·024		H =	·021		H =	...		H =	·007
	κ =	155°·15		κ =	32°·27		κ =	...		κ =	297°·24

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·007	187°·08	·007	125°·95
„ Fortnightly „ . . .	·043	259·07	·037	4·48
Luni-Solar „ „ . . .	·011	271·38	·011	258·80
Solar-Annual „ . . .	·289	243·11	·289	313·80
„ Semi-Annual „ . . .	·109	295·87	·109	77·25

Values of the Tidal Constants, Madras, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Madras; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

$A_0 = 2{\cdot}353$ feet.

S_1	H = R =	·035	M_6	R =	·009	Q_1	R =	·006	T_2	R =	·027
	κ = ζ =	65°·52		ζ =	44°·00		ζ =	10°·31		ζ =	220°·44
S_2	H = R =	·435		H =	·009		H =	·005		H =	·027
	κ = ζ =	271°·25		κ =	114°·30		κ =	175°·81		κ =	284°·69
S_4	H = R =	·003	M_8	R =	·001	L_2	R =	036	$(MS)_4$	R =	·008
	κ = ζ =	276°·12		ζ =	201°·80		ζ =	148°·93		ζ =	318°·30
S_6	H = R =	·001		H =	·001		H =	·030		H =	·008
	κ = ζ =	53°·97		κ =	175°·55		κ =	224°·20		κ =	221°·74
S_8	H = R =	·002	O_1	R =	·107	N_2	R =	·268	$(2S\,M)_2$	R =	·015
	κ = ζ =	304°·70		ζ =	173°·02		ζ =	311°·75		ζ =	100°·78
				H =	·104		H =	·268		H =	·015
				κ =	322°·22		κ =	231°·50		κ =	197°·35

Short Period Tides—contd.

A_0=2·353 feet.

M_1	R =	·009	K_1	R =	·311	λ_2	R =	...	$2N_2$	R =	·051
	ζ =	178°·07		ζ =	220°·68		ζ =	...		ζ =	277°·99
	H =	·008		H =	·305		H =	...		H =	·051
	κ =	344°·93		κ =	338°·78		κ =	...		κ =	214°·04
M_2	R =	1·067	K_2	R =	·105	ν_2	R =	·086	$(M_2N)_4$	R =	·022
	ζ =	339°·20		ζ =	199°·06		ζ =	96°·51		ζ =	33°·46
	H =	1·069		H =	·102		H =	·086		H =	·022
	κ =	242°·64		κ =	255°·01		κ =	249°·21		κ =	216°·64
M_3	R =	·005	P_1	R =	·106	μ_2	R =	·047	$(M_2K_1)_3$	R =	·013
	ζ =	215°·94		ζ =	101°·28		ζ =	353°·15		ζ =	280°·43
	H =	·005		H =	·106		H =	·047		H =	·013
	κ =	71°·10		κ =	334°·48		κ =	160°·02		κ =	301°·97
M_4	R =	·008	J_1	R =	·021	R_2	R =	...	$(2M_2K_1)_3$	R =	·006
	ζ =	29°·48		ζ =	225°·00		ζ =	...		ζ =	20°·90
	H =	·008		H =	·020		H =	...		H =	·006
	κ =	196°·35		κ =	322°·93		κ =	...		κ =	69°·66

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·044	36°·33	·044	20°·02
„ Fortnightly „ . . .	·035	217·74	·033	2·78
Luni-Solar „ „ . . .	·030	25·25	·030	121·82
Solar-Annual „ . . .	·408	346·57	·408	203·37
„ Semi-Annual „ . . .	·219	41·32	·219	114·92

Values of the Tidal Constants, Cocanada, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Cocanada; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 5·308 feet.

S_1	H = R =	·038	M_6	R =	·018	Q_1	R =	·001	T_2	R =	·011
	κ = ζ =	81°·31		ζ =	128°·66		ζ =	318°·37		ζ =	3°·74
S_2	H = R =	·648		H =	·018		H =	·001		H =	·011
	κ = ζ =	284°·73		κ =	95°·24		κ =	325°·01		κ =	276°·22
S_4	H = R =	·007	M_8	R =	·003	L_2	R =	·049	$(MS)_4$	R =	·024
	κ = ζ =	121°·66		ζ =	341°·57		ζ =	127°·49		ζ =	11°·26
S_6	H = R =	·002		H =	·003		H =	·046		H =	·024
	κ = ζ =	142°·43		κ =	57°·01		κ =	266°·69		κ =	120° 12
S_8	H = R =	·002	O_1	R =	·143	N_2	R =	·320	$(2SM)_2$	R =	·014
	κ = ζ =	24°·23		ζ =	129°·43		ζ =	334°·14		ζ =	64°·96
				H =	·135		H =	·322		H =	·014
				κ =	331°·70		κ =	247°·37		κ =	156°·10
M_1	R =	·016	K_1	R =	·357	λ_2	R =	...	$2N_2$	R =	·042
	ζ =	305°·71		ζ =	68°·79		ζ =	...		ζ =	169°·67
	H =	·010		H =	·344		H =	...		H =	·042
	κ =	56°·66		κ =	339° 03		κ =	...		κ =	247°·28
M_2	R =	1·506	K_2	R =	·194	ν_2	R =	·091	$(M_2N)_4$	R =	·044
	ζ =	143°·00		ζ =	279°·35		ζ =	153° 12		ζ =	67°·97
	H =	1·517		H =	·180		H =	·092		H =	·045
	κ =	251°·86		κ =	279°·41		κ =	208°·57		κ =	90°·07
M_3	R =	·009	P_1	R =	·091	μ_2	R =	·014	$(M_2K_1)_3$	R =	·015
	ζ =	32°·81		ζ =	260°·31		ζ =	54°·22		ζ =	294°·21
	H =	·009		H =	·091		H =	·014		H =	·014
	κ =	16°·10		κ =	341°·72		κ =	271°·94		κ =	313°·30
M_4	R =	·033	J_1	R =	·024	R_2	R =	...	$(2M_2K_1)_3$	R =	·007
	ζ =	245°·63		ζ =	197°·75		ζ =	...		ζ =	9° 87
	H =	·034		H =	·023		H =	...		H =	·007
	κ =	103°·35		κ =	299°·98		κ =	...		κ =	317°·35

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·054	249°·70	·056	85°·32
„ Fortnightly „ . . .	·083	100·56	·073	344·89
Luni-Solar „ „ . . .	·013	163·07	·013	54·21
Solar-Annual „ . . .	·763	182·20	·763	100·79
„ Semi-Annual „ . . .	·237	68·60	·237	85·78

Values of the Tidal Constants, Kidderpore, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Kidderpore; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 011·364 feet.

S_1	H = R =	·081	M_6	R =	·144	Q_1	R =	·043	T_2	R =	·115
	κ = ζ =	195°·60		ζ =	62°·49		ζ =	357°·86		ζ =	154·13
S_2	H = R =	1·498		H =	·147		H =	·041		H =	·115
	κ = ζ =	97°·39		κ =	328°·58		κ =	351°·07		κ =	75°·49
S_4	H = R =	·093	M_8	R =	·065	L_2	R =	·186	$(MS)_4$	R =	·677
	κ = ζ =	112°·92		ζ =	53°·93		ζ =	190°·31		ζ =	109°·39
S_6	H = R =	·003		H =	·066		H =	·172		H =	·682
	κ = ζ =	101°·69		κ =	288°·72		κ =	71°·21		κ =	78°·08
S_8	H = R =	·004	O_1	R =	·212	N_2	R =	·685	$(2SM)_2$	R =	·071
	κ = ζ =	187°·13		ζ =	312°·83		ζ =	158°·39		ζ =	335°·92
				H =	·200		H =	·690		H =	·071
M_1	R =	·016		κ =	23°·86		κ =	49°·27		κ =	7°·22
	ζ =	304°·10	K_1	R =	·399	λ_2	R =	...	$2N_2$	R =	·101
	H =	·010		ζ =	152°·18		ζ =	...		ζ =	230°·44
	κ =	163°·96		H =	·385		H =	...		H =	·102
M_2	R =	3·547		κ =	53°·50		κ =	...		κ =	43°·49
	ζ =	87°·85	K_2	R =	·458	ν_2	R =	·280	$(M_2N)_4$	R =	·147
	H =	3·572		ζ =	109°·42		ζ =	344°·55		ζ =	35°·99
	κ =	56°·55		H =	·427		H =	·282		H =	·149
M_3	R =	·024		κ =	91°·67		κ =	1°·87		κ =	255°·57
	ζ =	341°·80	P_1	R =	·120	μ_2	R =	·220	$(M_2K_1)_3$	R =	·139
	H =	·024		ζ =	313°·03		ζ =	253°·05		ζ =	150°·92
	κ =	294°·85		H =	·120		H =	·224		H =	·135
M_4	R =	·732		κ =	43°·34		κ =	190°·44		κ =	20°·94
	ζ =	98°·12	J_1	R =	·005	R_2	R =	...	$(2M_2K_1)_3$	R =	·033
	H =	·743		ζ =	86°·76		ζ =	...		ζ =	281°·84
	κ =	35°·52		H =	·005		H =	...		H =	·032
				κ =	62°·25		κ =	...		κ =	317°·92

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·393	278°·16	·404	355°·98
„ Fortnightly „ . . .	·293	12·04	·260	18·68
Luni-Solar „ „ . . .	·887	10·07	·893	41·37
Solar-Annual „ . . .	3·554	153·79	3·554	153·49
„ Semi-Annual „ . . .	1·177	330·06	1·177	329·46

Values of the Tidal Constants, Kidderpore, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Kidderpore; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

A_0 = 11·232 feet.

S_1	H = R =	·087	M_6	R =	·147	Q_1	R =	·034	T_2	R =	·180
	κ = ζ =	184°·76		ζ =	359°·13		ζ =	12°·18		ζ =	194°·15
S_2	H = R =	1·520		H =	·145		H =	·034		H =	·180
	κ = ζ =	98°·45		κ =	322°·92		κ =	354°·06		κ =	115°·26
S_4	H = R =	·099	M_8	R =	·058	L_2	R =	·215	$(MS)_4$	R =	·697
	κ = ζ =	113°·79		ζ =	70°·61		ζ =	39°·37		ζ =	207°·75
S_6	H = R =	·002		H =	·056		H =	·175		H =	·694
	κ = ζ =	104°·62		κ =	262°·33		κ =	74°·15		κ =	75°·68
S_8	H = ζ =	·001	O_1	R =	·209	N_2	R =	·731	$(2SM)_2$	R =	·063
	κ = ζ =	236°·31		ζ =	54°·18		ζ =	163°·98		ζ =	240°·45
				H =	·210		H =	·727		H =	·063
				κ =	25°·17		κ =	42°·61		κ =	12°·52
M_1	R =	·033	K_1	R =	·389	λ_2	R =	…	$2N_2$	R =	·145
	ζ =	145°·35		ζ =	154°·36		ζ =	…		ζ =	119°·78
	H =	·033		H =	·390		H =	…		H =	·145
	κ =	68°·30		κ =	55°·40		κ =	…		κ =	9°·51
M_2	R =	3·657	K_2	R =	·403	ν_2	R =	·343	$(M_2N)_4$	R =	·057
	ζ =	188°·04		ζ =	112°·02		ζ =	292°·99		ζ =	66°·17
	H =	3·638		H =	·413		H =	·341		H =	·056
	κ =	55°·97		κ =	94°·09		κ =	20°·07		κ =	172°·93
M_3	R =	·030	P_1	R =	·133	μ_2	R =	·224	$(M_2K_1)_3$	R =	·079
	ζ =	287°·62		ζ =	312°·25		ζ =	90°·26		ζ =	249°·70
	H =	·030		H =	·133		H =	·222		H =	·078
	κ =	269°·52		κ =	42°·32		κ =	186°·12		κ =	18°·67
M_4	R =	·750	J_1	R =	·009	R_2	R =	…	$(2M_2K_4)_3$	R =	·020
	ζ =	297°·85		ζ =	171°·96		ζ =	…		ζ =	146°·80
	H =	·742		H =	·009		H =	…		H =	·020
	κ =	33°·71		κ =	58°·00		κ =	…		κ =	341°·63

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·316	5°·17	·311	354°·27
„ Fortnightly „	·219	275·54	·221	21·49
Luni-Solar „ „	·987	272·17	·982	44·24
Solar-Annual „	2·837	159·32	2·837	159·25
„ Semi-Annual „	·900	336·66	·900	336·53

Values of the Tidal Constants, Chittagong, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Chittagong; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 7·977 feet.

S_1	H = R =	·067	M_6	R =	·139	Q_1	R =	·036	T_2	R =	·106
	κ = ζ =	106°·70		ζ =	88°·12		ζ =	46°·57		ζ =	95°·74
S_2	H = R =	1·571		H =	·143		H =	·034		H =	·106
	κ = ζ =	69°·88		κ =	196°·04		κ =	359°·00		κ =	302°·21
S_4	H = R =	·054	M_8	R =	·028	L_2	R =	·339	$(MS)_4$	R =	·334
	κ = ζ =	66°·66		ζ =	112°·91		ζ =	326°·97		ζ =	107°·43
S_6	H = R =	·010		H =	·029		H =	·342		H =	·338
	κ = ζ =	150°·83		κ =	136°·80		κ =	70°·35		κ =	23°·40
S_8	H = R =	·004	O_1	R =	·313	N_2	R =	·816	$(2SM)_2$	R =	·132
	κ = ζ =	215°·91		ζ =	68°·67		ζ =	97°·47		ζ =	212°·40
				H =	·293		H =	·824		H =	·133
				κ =	11°·72		κ =	22°·81		κ =	296°·42

Short Period Tides—contd.

$A_0 = 7{\cdot}977$ feet.

M_1	R =	·010	K_1	R =	·640	λ_2	R =	...	$2N_2$	R =	·111
	ζ =	88°·85		ζ =	44°·70		ζ =	...		ζ =	119°·35
	H =	·006		H =	·613		H =	...		H =	·112
	κ =	110°·16		κ =	21°·14		κ =	..		κ =	54°·06
M_2	R =	4·402	K_2	R =	·501	ν_2	R =	·365	$(M_2N)_4$	R =	·164
	ζ =	120°·51		ζ =	293°·14		ζ =	213°·38		ζ =	55°·78
	H =	4·445		H =	·458		H =	·368		H =	·167
	κ =	36°·49		κ =	65°·57		κ =	38°·03		κ =	257°·10
M_3	R =	·012	P_1	R =	·219	μ_2	R =	·295	$(M_2K_1)_3$	R =	·138
	ζ =	107°·07		ζ =	17°·12		ζ =	5°·46		ζ =	56°·22
	H =	·012		H =	·219		H =	·300		H =	·134
	κ =	161°·03		κ =	32°·52		κ =	197°·41		κ =	308°·63
M_4	R =	·410	J_1	R =	·063	2	R =	...	$(2M_2K_1)_3$	R =	·074
	ζ =	154°·34		ζ =	96°·39		ζ =	...		ζ =	57°·74
	H =	·418		H =	·059		H =	...		H =	·073
	κ =	346°·29		κ =	59°·94		κ =	...		κ =	273°·24

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·244	351°·03	·253	341°·66
„ Fortnightly „	·213	169·08	·184	19·53
Luni-Solar „ „	·439	314·79	·443	38·82
Solar-Annual „	1·877	59·92	1·877	134·51
„ Semi-Annual „	·158	115·57	·158	264·76

Values of the Tidal Constants, Akyab, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Akyab; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

$A_0 = 7{\cdot}535$ feet.

S_1	H = R =	·049	M_6	R =	·022	Q_1	R =	·018	T_2	R =	·109
	κ = ζ =	75°·32		ζ =	127°·67		ζ =	319°·47		ζ =	47°·63
S_2	H = R =	1·146		H =	·023		H =	·017		H =	·109
	κ = ζ =	307°·38		κ =	123°·84		κ =	268°·24		κ =	281°·69
S_4	H = R =	·007	M_8	R =	·007	L_2	R =	·124	$(MS)_4$	R =	·019
	κ = ζ =	179°·13		ζ =	281°·31		ζ =	243°·23		ζ =	358°·41
S_6	H = R =	·003		H =	·008		H =	·121		H =	·019
	κ = ζ =	53°·97		κ =	156°·20		κ =	302°·72		κ =	237°·13
S_8	H = R =	·001	O_1	R =	·194	N_2	R =	·528	$(2SM)_2$	R =	·030
	κ = ζ =	85°·60		ζ =	41°·14		ζ =	17°·28		ζ =	87°·52
				H =	·182		H =	·533		H =	·031
				κ =	334°·69		κ =	271°·22		κ =	208°·80
M_1	R =	·005	K_1	R =	·466	λ_2	R =	...	$2N_2$	R =	·090
	ζ =	324°·06		ζ =	34°·55		ζ =	...		ζ =	344°·55
	H =	·003		H =	·447		H =	...		H =	·091
	κ =	324°·04		κ =	343°·30		κ =	...		κ =	253°·72
M_2	R =	2·538	K_2	R =	·357	ν_2	R =	·195	$(M_2N)_4$	R =	·040
	ζ =	39°·14		ζ =	227°·40		ζ =	152°·72		ζ =	335°·03
	H =	2·561		H =	·328		H =	·197		H =	·041
	κ =	277°·86		κ =	304°·48		κ =	257°·02		κ =	107°·70
M_3	R =	·019	P_1	R =	·137	μ_2	R =	·024	$(M_2K_1)_3$	R =	·032
	ζ =	23°·44		ζ =	305°·04		ζ =	204°·50		ζ =	306°·91
	H =	·020		H =	·137		H =	·024		H =	·031
	κ =	21°·52		κ =	348°·04		κ =	321°·95		κ =	134°·39
M_4	R =	·006	J_1	R =	·031	R_2	R =	...	$(2M_2K_1)_3$	R =	·012
	ζ =	157°·22		ζ =	56°·98		ζ =	...		ζ =	258°·79
	H =	·006		H =	·029		H =	...		H =	·011
	κ =	274°·66		κ =	346°·94		κ =	...		κ =	67°·48

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·021	256°·97	·022	241°·74
„ Fortnightly „	·103	156·31	·090	347·05
Luni-Solar „ „	·059	289·54	·060	50·81
Solar-Annual „	1·138	97·54	1·138	144·54
„ Semi-Annual „	·112	71·70	·112	165·70

Values of the Tidal Constants, Rangoon, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Rangoon; and also the *mean* values of the amplitudes (H) and of the epochs (κ') for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 10·598 feet.

S_1	H = R =	·114	M_6	R =	·193	Q_1	R =	·025	T_2	R =	·136
	κ = ζ =	132°·45		ζ =	82°·24		ζ =	351°·36		ζ =	230°·82
S_2	H = R =	2·144		H =	·197		H =	·024		H =	·136
	κ = ζ =	169°·40		κ =	85°·94		κ =	72°·56		κ =	172°·90
S_4	H = R =	·079	M_8	R =	·074	L_2	R =	·406	$(MS)_4$	R =	·426
	κ = ζ =	252°·46		ζ =	328°·56		ζ =	43°·76		ζ =	92°·91
S_6	H = R =	·012		H =	·076		H =	·369		H =	·429
	κ = ζ =	25°·71		κ =	93°·49		κ =	161°·75		κ =	214°·15
S_8	H = R =	·003	O_1	R =	·299	N_2	R =	1·060	$(2SM)_2$	R =	·191
	κ = ζ =	100°·89		ζ =	142°·50		ζ =	160°·65		ζ =	175°·13
				H =	·283		H =	1·067		H =	·192
				κ =	26°·88		κ =	118°·71		κ =	53°·90
M_1	R =	·047	K_1	R =	·697	λ_2	R =	...	$2N_2$	R =	·223
	ζ =	64°·47		ζ =	152°·31		ζ =	...		ζ =	331°·00
	H =	·032		H =	·674		H =	...		H =	·225
	κ =	178°·15		κ =	32°·86		κ =	...		κ =	125°·88
M_2	R =	5·794	K_2	R =	·653	ν_2	R =	·254	$(M_2N)_4$	R =	·112
	ζ =	9°·83		ζ =	222°·44		ζ =	31°·84		ζ =	319°·27
	H =	5·832		H =	·611		H =	·256		H =	·113
	κ =	131°·06		κ =	163°·16		κ =	79°·59		κ =	38°·56
M_3	R =	·016	P_1	R =	·174	μ_2	R =	·577	$(M_2K_1)_3$	R =	·193
	ζ =	183°·37		ζ =	303°·37		ζ =	49°·47		ζ =	85°·51
	H =	·016		H =	·174		H =	·585		H =	·187
	κ =	185°·22		κ =	54°·39		κ =	291°·94		κ =	87°·29
M_4	R =	·450	J_1	R =	·015	R_2	R =	...	$(2M_2K_1)_3$	R =	·128
	ζ =	289°·85		ζ =	319°·44		ζ =	...		ζ =	52°·55
	H =	·455		H =	·014		H =	...		H =	·125
	κ =	172°·31		κ =	359°·48		κ =	...		κ =	54°·47

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·209	185°·16	·214	348°·34
„ Fortnightly „ . . .	·130	206·02	·116	18·51
Luni-Solar „ „ . . .	·522	168·56	·526	47·32
Solar-Annual „ . . .	1·535	164·09	1·535	143·07
„ Semi-Annual „ . . .	·370	17·42	·370	335·38

Values of the Tidal Constants, Rangoon, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Rangoon; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

A_0 = 10·523 feet.

S_1	H =	·125	M_6	R =	·204	Q_1	R =	·017	T_2	R =	·254
	κ = ζ =	126°·34		ζ =	23°·54		ζ =	356°·59		ζ =	180°·91
S_2	H = R =	2·102		H =	·200		H =	·017		H =	·254
	κ = ζ =	170°·60		κ =	84°·99		κ =	66°·41		κ =	122°·74
S_4	H = R =	·086	M_8	R =	·079	L_2	R =	·451	$(MS)_4$	R =	·409
	κ = ζ =	259°·37		ζ =	7°·64		ζ =	219°·52		ζ =	192°·06
S_6	H = R =	·012		H =	·077		H =	·368		H =	·407
	κ = ζ =	46°·41		κ =	89°·56		κ =	131°·28		κ =	212°·55
S_8	H = R =	·005	O_1	R =	·287	N_2	R =	1·083	$(2SM)_2$	R =	·175
	κ = ζ =	138°·01		ζ =	242°·48		ζ =	174° 12		ζ =	72°·05
				H =	·289		H =	1·077		H =	·174
				κ =	26°·75		κ =	120°·15		κ =	51°·56
M_1	R =	·076	K_1	R =	·659	λ_2	R =	...	$2N_2$	R =	·226
	ζ =	342°·16		ζ =	155°·05		ζ =	...		ζ =	222°·14
	H =	·074		H =	·661		H =	...		H =	·225
	κ =	156°·85		κ =	35°·36		κ =	...		κ =	93°·71
M_2	R =	5·851	K_2	R =	·666	ν_2	R =	·463	$(M_2N)_4$	R =	·247
	ζ =	111°·33		ζ =	228°·08		ζ =	340°·72		ζ =	59°·78
	H =	5·810		H =	·686		H =	·461		H =	·244
	κ =	131°·81		κ =	168°·73		κ =	98°·24		κ =	26°·29
M_3	R =	·023	P_1	R =	·165	μ_2	R =	·530	$(M_2K_1)_3$	R =	·174
	ζ =	304°·97		ζ =	305°·53		ζ =	251°·58		ζ =	163°·29
	H =	·023		H =	·165		H =	·524		H =	·173
	κ =	335°·69		κ =	56°·31		κ =	292°·54		κ =	64°·09
M_4	R =	·436	J_1	R =	·037	R_2	R =	...	$(2M_2K_1)_3$	R =	·132
	ζ =	130°·55		ζ =	132°·25		ζ =	...		ζ =	253°·14
	H =	·430		H =	·037		H =	...		H =	·131
	κ =	171°·51		κ =	82°·92		κ =	...		κ =	53°·79

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·195	308°·48	·191	22°·94
„ Fortnightly „	·167	111·58	·170	23·52
Luni-Solar „ „	·495	64·56	·492	44·08
Solar-Annual „	1·130	178·14	1·130	157·36
„ Semi-Annual „	·159	83·73	·159	42·17

Values of the Tidal Constants, Mergui, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Mergui; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 12·983 feet.

S_1	H = R =	·073	M_6	R =	·069	Q_1	R =	·028	T_2	R =	·240
	κ = ζ =	72°·64		ζ =	251°·39		ζ =	232°·25		ζ =	30°·97
S_2	H = R =	2·912		H =	·070		H =	·026		H =	·240
	κ = ζ =	350°·45		κ =	232°·72		κ =	265°·00		κ =	313°·34
S_4	H = R =	·046	M_8	R =	·016	L_2	R =	·259	$(MS)_4$	R =	·143
	κ = ζ =	243°·10		ζ =	92°·15		ζ =	25°·77		ζ =	187°·99
S_6	H = R =	·018		H =	·017		H =	·240		H =	·144
	κ = ζ =	94°·55		κ =	67°·26		κ =	278°·28		κ =	181°·77
S_8	H = R =	·001	O_1	R =	·220	N_2	R =	1·061	$(2SM)_2$	R =	·204
	κ = ζ =	114°·78		ζ =	218°·05		ζ =	22°·36		ζ =	123°·99
				H =	·208		H =	1·068		H =	·206
				κ =	315°·18		κ =	311°·75		κ =	130°·21

Short Period Tides—contd.

$A_0 = 12{\cdot}983$ feet.

M_1	R =	·022	K_1	R =	·537	λ_2	R =	...	$2N_2$	R =	·161
	ζ =	259°·60		ζ =	74°·22		ζ =	...		ζ =	81°·09
	H =	·015		H =	·518		H =	...		H =	·162
	κ =	131°·89		κ =	334°·53		κ =	...		κ =	306°·09
M_2	R =	5·446	K_2	R =	·911	ν_2	R =	·260	$(M_2N)_4$	R =	·222
	ζ =	317°·80		ζ =	7°·36		ζ =	202°·17		ζ =	256°·63
	H =	5·486		H =	·848		H =	·262		H =	·226
	κ =	311°·57		κ =	347°·58		κ =	256°·21		κ =	179°·80
M_3	R =	·050	P_1	R =	·160	μ_2	R =	·434	$(M_2K_1)_3$	R =	·071
	ζ =	147°·31		ζ =	245°·43		ζ =	356°·96		ζ =	12°·31
	H =	·051		H =	·160		H =	·441		H =	·069
	κ =	137°·98		κ =	336°·74		κ =	344°·51		κ =	06°·40
M_4	R =	·118	J_1	R =	·025	R_2	R =	...	$(2M_2K_1)_3$	R =	·004
	ζ =	149°·01		ζ =	14°·65		ζ =	...		ζ =	17°·45
	H =	·120		H =	·024		H =	...		H =	·004
	κ =	136°·56		κ =	335°·68		κ =	...		κ =	104°·69

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·047	286°·13	·048	350°·51
„ Fortnightly „ . . .	·011	17·82	·010	357·34
Luni-Solar „ „ . . .	·023	340·72	·023	346·94
Solar-Annual „ . . .	·645	140·31	·645	139·00
„ Semi-Annual „ . . .	·108	101·63	·108	99·00

Values of the Tidal Constants, Port Blair, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Port Blair; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

$A_0 = 4{\cdot}605$ feet.

S_1	H = R =	·017	M_6	R =	·001	Q_1	R =	·025	T_2	R =	·024
	κ = ζ =	58°·87		ζ =	221°·63		ζ =	229°·84		ζ =	33°·62
S_2	H = R =	·966		H =	·001		H =	·024		H =	·024
	κ = ζ =	311°·93		κ =	240°·62		κ =	227°·32		κ =	287°·40
S_4	H = R =	·002	M_8	R =	·002	L_2	R =	·071	$(MS)_4$	R =	·013
	κ = ζ =	239° 93		ζ =	291° 04		ζ =	343°·53		ζ =	255°·16
S_6	H = R =	·001		H =	·002		H =	·068		H =	·013
	κ = ζ =	138°·81		κ =	316°·36		κ =	268°·71		κ =	261°·49
S_8	H = R =	·002	O_1	R =	·167	N_2	R =	·414	$(2SM)_2$	R =	·028
	κ = ζ° =	36°·25		ζ =	218°·93		ζ =	349°·19		ζ =	150°·77
				H =	·157		H =	·417		H =	·028
				κ =	299°·89		κ =	272°·04		κ =	144°·44
M_1	R =	·009	K_1	R =	·408	λ_2	R =	...	$2N_2$	R =	·074
	ζ =	293°·63		ζ =	37°·12		ζ =	...		ζ =	73°·72
	H =	·006		H =	·393		H =	...		H =	·075
	κ =	175° 37		κ =	326°·10		κ =	...		κ =	273°·09
M_2	R =	1·974	K_2	R =	·290	ν_2	R =	·126	$(M_2N)_4$	R =	·081
	ζ =	270°·52		ζ =	274°·48		ζ =	143°·53		ζ =	231°·02
	H =	1·990		H =	·268		H =	·127		H =	·083
	κ =	275° 85		κ =	312°·03		κ =	241°·76		κ =	160°·20
M_3	R =	·005	P_1	R =	·121	μ_2	R =	·089	$(M_2K_1)_3$	R =	·016
	ζ =	30° 02		ζ =	263°·10		ζ =	272°·03		ζ =	315°·00
	H =	·005		H =	·121		H =	·090		H =	·016
	κ =	39° 51		κ =	325°·82		κ =	284°·69		κ =	250°·32
M_4	R =	·006	J_1	R =	·016	R_2	R =	...	$(2M_2K_1)_3$	R =	·007
	ζ =	80°·54		ζ =	290°·76		ζ =	...		ζ =	132°·17
	H =	·006		H =	·015		H =	...		H =	·007
	κ =	93°·20		κ =	299°·62		κ =	...		κ =	215°·84

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·019	177°·29	·020	260°·77
„ Fortnightly „ . . .	·049	349·74	·043	14·16
Luni-Solar „ „ . . .	·012	100·73	·012	94·40
Solar-Annual „ . . .	·277	125 48	·277	152·77
„ Semi-Annual „ . . .	·027	180·10	·027	234·66

The Tide Tables.

In addition to the calculations already mentioned, the usual work has been done in connection with the issue of the Tide Tables for 1891 (which were received in my office on the 3rd January 1891, and were distributed the same day), and with the preparation of those for 1892. In connection with the latter the values of the constants, which were calculated in the usual manner, were sent to Mr. Roberts ready for use in the Tide Predictor; and in addition he was furnished with the actual values during 1890 of high and low water at 16 stations, measured in duplicate from the tidal diagrams, together with similar data for the same year at Moulmein, kindly supplied by Captain Dodd, the Port Officer, who, since the tidal observatory was closed in 1886, has been regularly sending us personal observations from a graduated staff taken at the site of the observatory. In order to save Mr. Roberts the labour of the calculation, all the predicted times and heights of high and low water for 1890 at these 17 stations were compared with the above-mentioned actual values and the errors tabulated, thus giving him, in a convenient form, information which will enable him to improve the predictions where necessary.

The volumes of Tide Tables for 1892 will contain predictions for 31 tidal stations, no new station having been added since the last issue.

The amount realised by the sale of the tide tables has been steadily increasing year by year, and the limited number of presentation copies are distributed strictly in accordance with the lists sanctioned by Government.

The newly established tidal observatories at Minicoy and Trincomalee not having been in operation for a year, the values of their final datum lines with reference to mean sea-level cannot as yet be given.

The usual tabular statements are appended, showing the percentage and amount of the errors in the predicted times and height of high and low water for the year 1890 at 17 stations, as determined by comparison of the predictions entered in the tide tables for that year with the values obtained by actual measurement.

No. 1.

Statement showing the percentage and the amount of the Errors in the Predicted Times of High Water at the various Tidal Stations for the year 1890.

Stations.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	115	21	43	10	12	14
Kurrachee	698	21	43	18	15	3
Bhávnagar	704	31	40	12	12	5
Bombay { Apollo Bandar . .	705	33	49	11	6	1
Bombay { Prince's Dock . .	701	39	47	7	5	2
Cochin	691	24	34	12	22	8
Tuticorin	672	33	37	10	12	8
Galle	187	18	28	16	20	18
Colombo	162	21	29	10	19	21
Madras	536	38	37	12	10	3
Cocanada	706	46	44	6	3	1
Kidderpore	702	18	32	17	20	13
Chittagong	704	20	31	14	23	12
Akyab	694	46	44	5	4	1
Rangoon	704	24	35	12	22	7
Moulmein	365	37	41	11	9	2
Port Blair	694	20	37	14	17	12

No. 2.

Statement showing the percentage and the amount of the Errors in the Predicted Times of Low Water at the various Tidal Stations for the year 1890.

Stations.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	112	25	42	7	13	13
Kurrachee	702	35	41	12	9	3
Bhávnagar	699	24	37	11	17	11
Bombay { Apollo Bandar	705	32	43	11	11	3
Bombay { Prince's Dock	703	29	46	12	9	4
Cochin	695	38	44	6	9	3
Tuticorin	670	29	40	12	13	6
Galle	186	15	28	12	26	19
Colombo	162	21	43	17	12	7
Madras	535	35	38	12	11	4
Cocanada	705	42	43	8	5	2
Kidderpore	702	21	36	12	19	12
Chittagong	703	16	28	11	19	26
Akyab	695	43	41	10	5	1
Rangoon	702	28	36	9	18	9
Moulmein	365	35	36	8	9	12
Port Blair	690	21	32	16	14	17

No. 3.

Statement showing the percentage and the amount of the Errors in the Predicted Heights of High Water at the various Tidal Stations for the year 1890.

Stations.	Number of comparisons between the actual and predicted values.	Mean range at Springs in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
			Per cent.	Per cent.	Per cent.	Per cent.
Aden	646	6·7	89	11	...	...
Kurrachee	698	9·7	83	16	1	...
Bhávnagar	704	31·8	37	30	17	16
Bombay { Apollo Bandar	705	14·5	73	24	3	...
Bombay { Prince's Dock	701	14·6	63	28	8	1
Cochin	691	3·2	91	9	...	...
Tuticorin	672	3·2	77	22	1	...
Galle	187	2·2	92	8	...	...
Colombo	162	2·4	94	6	...	...
Madras	536	3·5	72	27	1	...
Cocanada	706	5·2	61	33	6	...
Kidderpore	702	11·7	35	23	15	27
Chittagong	704	13·5	34	26	22	18
Akyab	694	8·4	61	31	8	...
Rangoon	704	16·4	50	24	16	10
Moulmein	365	12·7	42	24	15	19
Port Blair	694	6·6	95	5	...	...

No. 4.

Statement showing the percentage and the amount of the Errors in the Predicted Heights of Low Water at the various Tidal Stations for the year 1890.

Stations.	Number of comparisons between the actual and predicted values.	Mean range at Springs in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
			Per cent.	Per cent.	Per cent.	Per cent.
Aden	640	6·7	92	8	...	...
Kurrachee	702	9·7	70	26	4	...
Bhávnagar	699	31·8	25	17	17	41
Bombay { Apollo Bandar	705	14·5	66	28	5	1
Bombay { Prince's Dock	703	14·6	56	31	11	2
Cochin	695	3·2	87	13	...	...
Tuticorin	670	3·2	83	17	...	...
Galle	186	2·2	91	9	...	...
Colombo	162	2·4	90	9	1	...
Madras	535	3·5	76	23	1	...
Cocanada	705	5·2	63	29	7	1
Kidderpore	702	11·7	31	21	15	33
Chittagong	703	13·5	42	24	15	19
Akyab	695	8·4	70	27	3	...
Rangoon	702	16·4	42	28	15	15
Moulmein	365	12·7	44	25	13	18
Port Blair	690	6·6	84	13	3	...

No. 5.

Table of Average Errors in the Predicted Times and Heights of High and Low Water at the several Tidal Stations for the year 1890.

Stations.	Mean Range at Springs in feet.	Average Errors					
		Of Time, in minutes.		Of Height, in terms of the Range.		Of Height, in inches.	
		H. W.	L. W.	H. W. Feet.	L. W. Feet.	H. W.	L. W.
Aden	6·7	15	15	·025	·025	2	2
Kurrachee	9·7	13	11	·026	·026	3	3
Bhávnagar	31·8	12	15	·018	·031	7	12
Bombay { Apollo Bandar	14·5	10	11	·017	·023	3	4
Bombay { Prince's Dock	14·6	9	11	·023	·029	4	5
Cochin	3·2	15	10	·052	·052	2	2
Tuticorin	3·2	13	13	·078	·078	3	3
Galle	2·2	19	20	·076	·076	2	2
Colombo	2·4	19	13	·069	·069	2	2
Madras	3·5	11	12	·071	·071	3	3
Cocanada	5·2	8	8	·064	·064	4	4
Kidderpore	11·7	17	16	·071	·078	10	11
Chittagong	13·5	16	21	·049	·049	8	8
Akyab	8·4	8	8	·040	·030	4	3
Rangoon	16·4	15	14	·030	·036	6	7
Moulmein	12·7	10	14	·046	·052	7	8
Port Blair	6·6	16	18	·025	·038	2	3

The foregoing statements may be summarised as follows:—

Percentage of Time predictions within 15 minutes of actuals.

	High water. Per cent.	Low water. Per cent.
13 Open coast stations	69	70
4 Riverain stations	60	59

Percentage of Height predictions within 8 inches of actuals.

	High water. Per cent.	Low water. Per cent.
13 Open coast stations	95	93
4 Riverain stations	65	64

Percentage of Height predictions agreeing with actuals within one-tenth of mean range at springs.

	High water. Per cent.	Low water. Per cent.
13 Open coast stations	91	91
4 Riverain stations	90	86

These figures show a slight falling off, chiefly in the time predictions, from the exceptionally good results obtained in 1889; they are nevertheless above the average, and may be considered on the whole to be very satisfactory.

Bench Marks.

During the year under report bench marks were laid down as follows:—

At the new station of Minicoy one embedded and four inscribed bench marks of reference were laid down and connected by spirit levelling with the bed plate of the tide gauge.

At the new station of Trincomalee two bench marks of reference were established and connected with the observatory. One has been placed on a large stone in the wharf wall 25 feet from the observatory door and bears the inscription $\underset{B.\ M.}{\square^{G.T.S.}}$, the other is the level surface of the sundial slate which is firmly fixed 3½ feet above the ground on the top of a solid granite pedestal about an equal distance from the observatory.

At Kidderpore, two new bench marks of reference were laid down and connected with the observatory; they each bear the inscription $\underset{B.\ M.}{\bigcirc^{G.T.S.}}$, and are situated respectively on the east and west coping of the main entrance of the new dock.

At Rangoon the bench mark selected as the principal bench mark of reference is known as Graham Smith's, which is a flat stone just outside the south-east corner of the walled enclosure of the Sailors' Home, bearing the inscription "G.S. *Datum* ○23·27 below this B.M." Two minor bench marks of reference have also been placed in the covered shed at Brooking Street wharf: each consists of the letters B.M. and a circle cut on the foot of an iron-supporting pillar, one at the north-west and the other at the south-west corner of the structure. All three bench marks have been connected with the bed plate of the tide gauge.

In addition to these bench marks of reference, 54 embedded bench marks (of which 2 are test bench marks), 352 inscribed or minor bench marks, 25 railway bench marks, 2

P. W. D. bench marks, and 2 Marine Survey bench marks were connected in the course of last season's levelling operations.

All the bench marks of reference at the tidal stations were found undisturbed and in a satisfactory condition without exception.

At Narel station of the Great Indian Peninsula Railway, embedded bench mark No. 48 of Spirit Levelled Heights, Nos. 2 and 3, Bombay Presidency and Nizam's Dominions, revised edition, 1886, was disturbed during structural alterations to the station. The Consulting Engineer was accordingly requested to destroy the bench mark, and the circumstance was reported to the Deputy Surveyor General in July, so that the necessary correction might be made in the pamphlet. As there are two permanently inscribed bench marks in the neighbourhood of Narel Railway station, it will not be necessary to place another embedded bench mark there.

The embedded test bench mark at Parambúr, No. $\frac{2}{17}$ of Spirit Levelled Heights. No. 1, Madras Presidency, seasons 1869—85, was tampered with and injured by the servants of the Carnatic Mill Company about the beginning of July. Messrs. Binny & Co. subsequently reported that it had been restored to its original condition, and it is proposed to re-level to it during the approaching field season when an officer is available for that duty, which will probably be when Cochin tidal observatory is being closed.

One more embedded bench mark was destroyed during the year under report, *viz.*, that at Lálápet Railway station, South Indian Railway, numbered 29 of Spirit Levelled Heights, No. 3, Madras Presidency, season 1886-87. The removal of this bench mark was absolutely necessary as it interfered with the extension of the siding accommodation; but as there are two permanently inscribed bench marks not far from it, its loss is not of sufficient importance to render necessary the establishment of another embedded bench mark in its place.

One inscribed bench mark was also destroyed, *viz.*, No. $\frac{1}{11}$, section I of Spirit Levelled Heights, Nos. 2 and 3, Bombay Presidency and Nizam's Dominions, 1877-89, revised edition. This bench mark was placed on the parapet of a bridge crossing the Mutha right bank canal from Khadakvásla, and it was rendered useless through the parapet having been raised in height.

About the middle of October 1889 the four following bench marks on the tops of milestones were struck off our lists as the milestones had to be removed:—

Nos. $\frac{2}{14}$, $\frac{7}{14}$, $\frac{8}{14}$, and $\frac{9}{14}$ of series IV, Spirit Levelled Heights, No. 4, Bombay Presidency, 1877-78, 1881-84.

Also in July 1890 intimation was received that, in consequence of alterations to the bridge close to the cantonment railway station at Bangalore, bench mark No. 4, section, Bangalore to Mangalore of Spirit Levelled Heights, No. 5, Madras Presidency, 1888-89, had been removed. This information is given here as it was omitted in last year's Annual Report.

Pairs of embedded bench marks, termed "Test Bench Marks," have been laid down from time to time in connection with the tidal observatories, their object being to detect secular changes of relative level between the land and the sea. The following table shows those which have been established up to the present time. They are laid down generally about 8 or 10 miles inland on solid ground and connected carefully with their respective tide gauges. According to orders received in 1884, they used to be placed in pairs, one on each side of the main line of levelling, and at least one mile distant from it. For some time this plan has been discontinued, as any embedded bench mark at a suitable distance from a tidal observatory answers the purpose of a test bench mark.

The following is a list of those at present existing:—

List of Test Bench Marks.

Tidal Observatory.	No. of Test Bench Mark published in pamphlet of Spirit Levelled Heights.	Approximate distance of Test Bench Mark from Observatory.
		Miles.
Kurrachee* . .	Inscribed B. M. on top step of front entrance of Kurrachee Church. Page 38, Tables of Heights in Sind, Punjab, &c., 1862.	7·3
Nowanar . .	No. 5. Series I, Bombay Presidency, No. 1, 1874—78 . .	9·6
	No. 4. Ditto ditto ditto . . .	6·0
Hanstal . .	No. 36. Ditto ditto ditto . . .	17·4
	No. 39. Ditto ditto ditto . . .	12·8
Okhá . . .	No. 42. Series II, Bombay Presidency, No. 1, 1874—78 . .	10·3
	No. 45. Ditto ditto ditto . . .	5·0
Bhávnagar . .	No. 105. Section Rájkot to Bhávnagar, 1890-91 . . .	14·5
	No. 114. Ditto ditto . . .	7·9
Bombay . . .	No. 7. Section I, Nos. 2 and 3 Bombay Presidency, 1877—80, revised edition.	5·0
	No. 10. Ditto ditto ditto . . .	9·0

* It is intended to erect a standard bench mark for Kurrachee, which will also be the principal test bench mark for the Kurrachee tidal observatory.

Tidal Observatory.	No. of Test Bench Mark published in pamphlet of Spirit Levelled Heights.	Approximate distance of Test Bench Mark from Observatory.
		Miles.
Mormugão	No. 33. Section Kárwár to Mormugão, No. 3 Madras Presidency, 1886-87.	17·1
	No. $\frac{3}{4}$. Ditto ditto ditto	16·7
Kárwár	No. 12. Ditto ditto ditto	9·7
	No. 14. Ditto ditto ditto	11·7
Beypore	No. $\frac{1}{1}\frac{1}{5}$. Section Jalárpet to Beypore, No. 1 Madras Presidency, 1869—85.	30·1
	No. $\frac{1}{1}\frac{1}{5}$. Ditto ditto ditto	30·1
Cochin	No. $\frac{1}{2}\frac{1}{2}$. Section Shoranur to Cochin, No. 3 Madras Presidency, 1886-87.	22·5
	No. 50. Ditto ditto ditto	21·1
Tuticorin	No. $\frac{1}{1}\frac{1}{4}$. Section Ramnad to Tuticorin, No. 2 Madras Presidency, 1885-86.	10·2
	No. $\frac{1}{1}\frac{1}{4}$. Ditto ditto ditto	9·8
Pámban	No. $\frac{1}{3}\frac{1}{6}$. Section Tanjore to Pámban, No. 2 Madras Presidency, 1885-86.	12·9
	No. 63. Ditto ditto ditto	12·2
Negapatam	No. $\frac{1}{1}\frac{1}{3}$. Section Madras to Nagapatam, No. 2 Madras Presidency, 1885-86.	8·6
	No. $\frac{1}{1}\frac{1}{3}$. Ditto ditto ditto	8·2
Madras	No. $\frac{1}{1}\frac{1}{5}$. Section Madras to Arkonam, No. 1 Madras Presidency, 1869—85.	6·3
	No. $\frac{1}{1}\frac{1}{5}$.* Ditto ditto ditto	6·5
Cocanada	No. 11. Section Cocanada to Vizagapatam, No. 4 Madras Presidency, 1887-88.	9·9
	No. 13. Ditto ditto ditto	11·5
Vizagapatam	No. 96. Ditto ditto ditto	10·7
	No. 99. Ditto ditto ditto	9·6
False Point	No. 4. Series I, Bengal Presidency, 1881-82-83 and 1887-88	8·6
	No. 17. Ditto ditto ditto	30·2
Kidderpore	Nos. $\frac{1}{7}\frac{1}{0}$ & $\frac{1}{7}\frac{1}{5}$. Series III, Bengal Presidency, 1881-82-83 and 1887-88.	3·7
	No. 7. Series VII. Ditto ditto ditto	10·5

Levelling Operations.

The levelling operations of the last field season comprised the following lines of double levelling:—

(*a*) Section from Rájkot along the Rájkot-Bhávnagar main road *viá* Sardhar, Adkot and Bábra to Dhása, and thence along the Bhávnagar-Gondal-Junagad-Porbandar Railway line to Bhávnagar.

(*b*) Section from Sanosra station of the Bhávnagar-Gondal-Junagad-Porbandar Railway to Chaúda temple opposite Sálbet, with a branch line to Port Albert Victor.

(*c*) Section from Náydongri Railway station along the north-east division of the Great Indian Peninsula Railway to Bhusával, and thence to Málkhed Railway station on the Nágpur line.

Their out-turn amounts to 425 miles of double levelling, in doing which the instruments were set up at 3,137 stations, and in the course of which three Great Trigonometrical Survey stations and the bench marks enumerated above were connected. This is a good out-turn, and it would have been larger had all the sections been continuous; but three weeks were lost in changing ground. Our thanks are due to the Engineers of the Bhávnagar-Gondal-Junagad-Porbandar and Great Indian Peninsula Railways for the help invariably afforded by them to Mr. Bond and his detachment, and to Mr. Proctor-Sims, who kindly deputed an Assistant Engineer to prepare in advance the necessary bench marks, and who gave the levelling detachment every help while it was working in the Bhávnagar State.

Extract from Notes by Mr. J. Bond, *Surveyor, 4th grade, on the levelling operations executed by him,—Season 1890-91.*

The levelling detachment proceeded by rail from Poona on the 24th October and on the following day embarked at Bombay on the B. I. S. N. Company's Steamer *Pemba* for Porbandar, where we landed on the night of the 26th and proceeded at once by rail to Dhoráji, where the camp equipment and instruments were stored on the completion of the work at the end of last field season.

The party left Dhoráji on the 29th October and marched *viá* Jetpur and Gondal to Rájkot, a distance of 60 miles, arriving there on the 2nd November. Here a few days were spent in attending to the repairs of stores, the adjustment of levels, in taking observations to determine the value of one division of the level scale, and in constructing a table of subtenses for cylindrical level.

I commenced work on the section Rájkot to Bhávnagar on the 6th November. This section emanated from the embedded bench mark at Rájkot (No. 15 of Series III of spirit levelled heights, No. 1 Bombay Presidency), laid down by Captain A. W. Baird, R.E., in field season 1875-76, and was carried along the Rájkot-Bhávnagar road to Dhása, and thence along the Bhávnagar-Gondal-Junagad-Porbandar Railway

* The level of this bench mark has to be re-determined.

line to Bhávnagar, and closed on the bench mark of reference of the Bhávnagar tidal observatory situated close to the incline plane of the steam ferry.

On the completion of the work at Bhávnagar on the 19th December, the party marched to Sanosra to take up the second section from Sanosra Railway station to Port Albert Victor and Sálbet. This section was started from the embedded bench mark at Sanosra Railway station on the 2nd January 1891, and was carried along the proposed railway line to Port Albert Victor *viá* the villages of Noghanwádar, Jesar, Khuntaora, and Dongar, and the well known tank called Potatalávr near the village of Pipalváv. To avoid the salt marsh, intersected with numerous tidal creeks, the line of levels was continued from Potatalav westward, skirting the salt waste and passing through the villages of Bherai and Ranparda across the mouth of the Dhántrávádi river to Chachúda temple.

As it was impossible to level across the sea to the island of Sálbet, the bench mark of reference, G. T. S. 3 O B. M. A. D. 1890. embedded in the low knoll at the north-east corner of Sálbet village in the vicinity of the proposed tidal observatory, was connected by means of 101 simultaneous tidal observations taken on the 26th, 27th, 28th and 29th January from about half an hour before high water to about half an hour after.

On the completion of the section to Sálbet on the 2nd February the staves were again compared with the standard bar, and on the following day the party left the island by boat, arriving at Jáfarabad the same evening, whence we proceeded by the Native passenger steamer *Krishna* to Bombay, and thence by rail to Náydongri, to take up the spirit levelling from Náydongri Railway station along the north-east division of the Great Indian Peninsula Railway to Bhusával and thence to Nágpur.

After the necessary arrangements to start the work had been made, I began operations on the 13th February from the bench mark (No. 13 of Series V of spirit levelled heights, No. 4 Bombay Presidency), embedded in the station platform at Náydongri (Great Indian Peninsula Railway), and continued the work uninterruptedly to Málkhed (Málker) Railway station on the Nágpur line, where the season's operations closed on the 11th May. On the following day the party marched to Amraoti.

After comparing the staves with the standard bar, arranging for the storage of the camp equipment, and settling with the Native establishment previous to their departure on leave, I returned to head-quarters by rail, arriving at Poona on the 17th May.

I may here remark that in the levelling from Náydongri towards Bhusával the present operations were carried over 60 miles of single levelling performed in season 1882-83 by sub-surveyor Vinayek Narayan, working with Dumpy level No. 734.

During the season I used cylindrical level No. 4 and staves Nos. B_1 B_2. Owing to an accident sustained by this level in 1888, a new spirit level had been fitted to it in Calcutta, but after its return the metal ring containing the antagonistic adjusting screws was found to be cracked, the crack running into one of the female screws. The instrument on trial was found to work well, but eventually the threads of the male screw wore away, and by the time I reached Bhávnagar the level became very unsteady, necessitating very tender handling and great loss of time in levelling the instrument. Mr. Proctor-Sims kindly had new screws made for the instrument, and on the next section I was able to get on much more rapidly.

Unfortunately on the section from Náydongri the carriers slipped and the shock to the instrument opened out the crack in the adjusting ring rendering the instrument useless. For 45 miles I had therefore to use Cushing's reversible level till I arrived at Akola, where the Resident Engineer, Mr. Hemans, had the ring cleverly repaired, and the instrument is now in excellent working order.

Sub-surveyor Narsing Das had in use cylindrical level No. 3, apparently a new instrument, which remained in excellent working order throughout the field season.

It will be seen from the following table that the differences of lengths of both pairs of staves from the 10 foot standard bar corrected for expansion are in defect, and this defect went on increasing as the season advanced, particularly staves N_1 and N_2, which being hollow were evidently much more affected by changes of temperature, and therefore the comparisons should have been made more frequently.

Results of comparison of staves.

Date of comparison.	Mean difference of length of pairs of staves from 10 feet.	
	Staves (solid) B_1 and B_2.	Staves (hollow) N_1 and N_2.
At Rájkot, 4th November 1890	—·000234	—·001414
At Sálbet, 1st February 1891	—·002202	—·006420
At Amraoti, 13th May 1891	—·002948	—·009707

FIRST MIRANZAI EXPEDITION.

Extract from the Report on the Survey Operations with the Miranzai Field Force, by CAPTAIN R. A. WAHAB, R.E., *Season 1890-91.*

The name Khanki is applied to the greater part of the valley of the Ghorbin Toi, the upper feeders of which, rising among the eastern spur of the Safed Koh, water the different glens of the Urakzai Tirah. Looking upstream from the high hills over Jandasam the river could be traced for a long distance running through an open valley, with wide stretches of level ground at intervals, into which the snow-covered hills sloped gently down. From Adugarhi, at the junction of the Daradar ravine with the main stream, the valley contracts, and thence down to its exit from the hills near Shahu Khel, it is more or less a defile flanked by high and, in places, precipitous hills, rising on an average 2,000 feet above the river bed. There are, however, numerous *kaches* or narrow strips of cultivation varying from 50 to 500 yards in breadth, and every available piece of level ground is made use of. Rice appears to be the chief product of the valley.

On the south, the crest of the Samana range runs parallel to and generally some two or three miles distant from the stream, into which it slopes abruptly in many places. Grass and firewood are found in abundance on all parts of the range; in places the trees, wild olive, holly and hill oak, grow to a considerable size, and thickly enough to give the hills a wooded appearance unusual on the north-west frontier.

On the north several ravines running down from the higher ranges break the continuity of the hills, immediately bordering the valley on that side. The most westerly of those explored was the Daradar valley, occupied by the Mamozai (Muhammadzai) section. Daradar (Starkili) is at the southern end of a small basin formed by the confluence of several hill streams, which rise under the high masses of the Mazioghar range. Several other villages lie within a radius of one and a half or two miles, and higher up, in a branch from the same valley, is Torsmats, a Shekhan village, and the furthest point reached by our reconnoitring parties. Immediately below Daradar the hills close in, and the stream forces its way through a narrow defile till it joins the Khanki, three miles to the south, at Adugarhi. Two and a half miles lower down another ravine runs in on the left bank near Nakshband, draining the Kama Karbogha basin, and at Nari a similar *tangi* comes down from Stara Karbogha. A mile below Khanrai, another tributary from the Ibrahimo and Kasha valley enters the Khanki. From here a pass leads to Dran in the Shekhan valley, which lies parallel to and about five miles north of the Khanki, and separated from the latter by a steep and rocky range of hills.

Dran consists of a group of four villages, situated in the broadest part of the Shekhan valley, here about half a mile across. Below Lakardara, the most easterly of the Shekhan villages, the valley contracts to a narrow, tortuous defile, which, if held by an active enemy, would prove a difficult one to force; it can, however, be turned by the pass leading from Kasha, which could be easily reached in one march from Shalu Khel. Above Dran the valley bifurcates, one branch leading to the Kharai Kotal above Daradar; the other, the northern, over a higher *kotal* by which a road leads to Torsmats. In both these branch valleys there are a few outlying Shekhan hamlets. The road to Daradar by the Kharai Kotal is good almost throughout, with the exception of the steep ascent from Mir China on the eastern side. There is a small plateau three-quarters of a mile long by half a mile broad at the summit, and a Mamozai hamlet on a knoll commanding the whole plateau, which would make an excellent position for a post.

Both the Khanki and Shekhan rivers join the Kohat Toi; the former at Rais, the latter at Kuz Ustarzai, on the Kohat-Thal road.

The Sturi Khel country lies in the valley of the Urakzai Toi; it was reached from Marai, at the head of the Samilzai valley, by an easy pass, though, owing to the heavy snowfall of the 10th February and the intense cold of the succeeding night, the march from Marai to Zera (only 5 miles) proved the most trying of the whole expedition. From Zera, where the force was encamped, the road leads up the rough bed of the river through a very difficult *tangi* for nearly two miles. From And Khel, the first of the Sturi villages, the valley opens out and for ten miles or more, as far as could be seen, the country appeared open and undulating, rather than mountainous. Numerous villages and towers, and the lines of terraced fields, showed up clearly amidst the snow which covered the whole valley.

Downstream from Zera the river runs between high hills south-east for about 10 miles to Usai; thence it sweeps round to the north-east, past the steep spurs of Mauleghar, till it joins the Bara river, some 10 miles above the Bara post in the Peshawar valley.

No opposition was met with at any time from the inhabitants, though the survey escorts never exceeded a strength of 12 sepoys; except in the Rabia Khel country, where the villages were deserted, the sepoys of the escort were always treated in the most friendly way by the villagers, and no difficulty was experienced in getting guides or any information about the country that was required. The most serious difficulty the surveyors had to contend with was due to the inclement weather; the deep snow on the higher hills, and the keen winds on the summits where it was necessary to climb in order to get any view of the country, were exceptionally trying.

The minimum temperature recorded was at Zera, where the thermometer stood at 21° at 7 A.M. on the 11th February; during the night it was doubtless several degrees colder, but I have no trustworthy record of the minimum night temperatures. The altitude of Zera is 3,880 feet above sea-level.

I am much indebted to Captain Mason, R.E., and the other Intelligence Officers working with him. Some reconnaissance sketches by Captain Bryan, R.A., have been of value in enabling me to fill up parts of the map, which I was unable to visit myself.

Second Miranzai Expedition.

Extract from the Report on the Survey Operations with the Miranzai Field Force, *by* Captain R. J. Mackenzie, R.E.,—*Season 1890-91.*

The Samana range is composed of limestone strata, often of great thickness, intermixed with soft loose soil. The top of the ridge, coinciding with a gentle anticlinal in these strata, consists in parts of its length of fairly level, rounded plateaux, while the broken edges of the limestone strata present impassable *khuds* on either side. The more

open parts are connected by narrow ridges where the range has been eaten away to a razor-back. Numerous spurs run north and south from the main range separated by deep and precipitous valleys. Both main range and spurs are crowned by villages which are nearly always built on commanding points. They nearly all contain, or rather did contain when the force arrived there, solid and well built towers.

Every available spot on the hillsides has been worked up with much labour into terraced fields, and the amount of cultivation is considerable. It nearly all depends on rainfall. Numerous tanks have been dug on the hillsides and crests, and furnish a large proportion of the water-supply of the country.

The upper part of the Khanki valley is much more open than the lower part described by Captain Wahab in his report after the first expedition. At Karapa, which may be considered the limit of the two parts, the Sampagha stream comes in from the north. It drains an open, fairly steep glacis-like slope, which contains the villages of Kandi Mishti as well as the Takhtak nala basin. To the north is the Sampagha pass over the Tsappar range. The latter guarded by towers of the Shekhans, Alikhels, and Mullakhels, which, perched on the top of the ridge, watch each other jealously. The pass appears quite easy, as does also the Arhanga pass into Maidan, which is only some three or four miles north-west of it.

Going up the valley from Karapa on the south are several small side valleys. On the north at Sadarai, six miles above Karapa, another open steep glacis like valley, containing several villages, slopes down to the river. Above this the valley opens out, and is well inhabited and cultivated on either bank, the river running in a deep channel.

On the south bank, at eleven miles from Karapa, is Starkili, the principal village, or rather collection of villages of the Alisherzais, and five miles further on, on the north side of the valley, is Khanki or Massozai Bazar. This latter is counted one of the two principal places in Tirah; Mishti Bazar in the Mastura valley being the other.

At Khanki Bazar the drainage of the Kahu, Kama, and Torsmats *nalas* comes in from the north. No view was obtained up these valleys, but they appear from native information to be well inhabited by Mamezais. The Kahu is one of the chief routes into Maidan and leads into the Kambarkhel territory. To prevent misapprehension, it may be noted that the *nala* on the far side of the *kotal* is also called Kahu, which name seems to apply to the whole road from Khanki to Maidan. Above Khanki Bazar the head of the valley is formed of rounded spurs coming down from the watershed and the hills on either side, and separated by deep ravines. Villages are numerous.

From the *kotal* a view was obtained of the Karmana Dara: it seems to be of the same character as the Khanki, and numerous villages were seen.

BLACK MOUNTAIN EXPEDITION.

Extract from the Report on the Survey Operations with the Hazara Field Force, by CAPTAIN R. A. WAHAB, R.E., *Season 1890-91.*

The description of the country given in my report on the last Hazara expedition (1888) need not be repeated here. The adjoining Chagarzai country is in most respects similar; the proportion of forest is perhaps smaller, and of land under cultivation somewhat greater, while the villages generally are larger and more compact than those of their Hasanzai or Akazai neighbours: fruit trees also are more numerous. On the left bank of the Indus little could be seen beyond Judba, the spur running up thence to the crest of the Black Mountain hiding all beyond: it was evident however that any road through the cis-Indus Chagarzai country, other than that along the river bank, or along the crest of the range, would be extremely difficult.

Across the river from Didal upwards, the country is less difficult, the hill slopes are more gentle, and the height of the main range is less. Nothing was seen of the Indus itself beyond the mouth of the Itai; Kabalgram, which lies a mile or two further north, being hidden by the Domel spur. The Itai valley is about 15 miles in length from its junction with the Indus to the Ghurband Pass; it appears to be well cultivated, the principal crops being *makkai* on the higher slopes and rice in the low-lying ground.

In the range bounding it to the north and west several conspicuous peaks rise to a considerable height, the highest just exceeding 10,000 feet. The main road from the Chagarzai country to Swat leads up this valley across the Ghurband Pass (7,000 feet). It is said to be fairly good, and passable by laden mules.

The roads along both banks of the Indus between Palosi and Takot were traversed by a Havildar of the 4th Sikh Infantry under the orders of the Intelligence Officer with the force, so that the course of the Indus can now be laid down with a fair amount of accuracy. His report proves that there is at present no practicable road continuously along either bank, and that it is necessary to cross the Indus either at the Marer ferry or near Kamach, re-crossing to the east bank some little distance above Kabalgram, above which point the road on the west bank is almost impracticable. One of the results of the expedition is that there is now a fair road along the east bank as far as Darbanai; and it is believed that if this were continued along the river bank to Judba the necessity for crossing the Indus would disappear. Some very heavy work would be necessary, but the advantages of a road, cis-Indus throughout, would amply repay the cost and labour.

The level of the surface of the Indus has been determined at several points. During the 1888 expedition, the level at Takot was fixed approximately at 1,700 feet; at the mouth

of the Itai river, 16 miles lower down, it is 1,500 feet, and the same distance lower down at Kunhar 1,320; this gives a fall of nearly 12 feet per mile. At Darband camp, 12 miles lower down the water-level, is about 1,200 feet, and from thence downwards the fall is much less rapid. Boats were brought up from Attock for the bridge-of-boats which was established at Kotkai, and small boats were taken up as far as the reach between Karnar and Palosi, and could have been taken up as far as Kamach without much difficulty. There is, however, a bad series of rapids between Kamach and Kotkai, beyond which it is extremely doubtful if boats could be taken; from this point upwards the only means of crossing the Indus that could be depended on would be *mussak*, rafts, or rafts formed of hollowed out logs, such as are in common use at all ferries on this part of the Indus.

EXPEDITION TO MOGAUNG, ENDAWGYI, ETC., BHAMO DISTRICT.

Extract from the Narrative Report of CAPTAIN F. B. LONGE, R.E., *in charge No. 21 Party, Season 1890-91.*

I received charge of the party from Major Hobday in Mandalay on 1st December, and the head-quarters were then transferred to Bhamo, where, immediately on our arrival, we proceeded to measure a base and endeavoured to extend the triangulation towards Mogaung. We visited a small hill above the village of Pin-thet on the Irrawaddy, and one above Nyetpyawdaw village, but owing to the dense jungle we were unable to do all we wanted.

On the 26th December, Lieutenant Gordon and I, with an escort of military police, went up the river in the 'Pathfinder' as far as the village of Nansauk, where we left the steamer. Next day I ascended the hill above the village and took some observations, and on the 28th I returned to Bhamo, leaving Lieutenant Gordon and the escort at Nansauk. On the 29th I left Bhamo again and went as far as Senbo, picking up Gordon *en route*.

While at Senbo I recommenced the triangulation from a base measured by Major Hobday, and observed from three stations fixing a certain number of points on ahead, but the weather was not very favourable, and I could not fix any very distant peaks. Those I did fix, however, were very useful, as they enabled me to determine accurately the relative position of Mogaung and Senbo, adopting the position of Senbo as determined previously by Major Hobday. Unfortunately the latitude of Senbo was incorrect, and consequently a portion of my work, before the error was discovered, was vitiated, and I had subsequently to work with observed latitudes.

On the 1st January, the remainder of the Bhamo portion of the column I was to accompany arrived at Senbo, and on the 3rd we started for Mogaung, marching as far as the Narsing Chaung; we reached Mogaung in five marches. On the 9th I observed from Umantaung hill station, and on the 10th measured a base in the paddy fields and observed from it.

At Umantaung I obtained a plane-table fixing, and with the plane-table value of latitude and longitude and an observed azimuth, computed the value of some of the points I had fixed from Senbo. The values now obtained agreed within 2 seconds of latitude and 2 seconds of longitude, which satisfactorily fixed the position of Mogaung, making it considerably east of its present position on the map.

From Mogaung a column under Captain O'Donnell was to have marched to Sana, and afterwards through the Kaukkwe valley, but in consequence of rumours of a large gathering of well-armed men in Thama, we were, after considerable delay, sent to that place, which we entered on 20th February without opposition. I was enabled to make some slight additions and corrections to the survey made of this country by Mr. Ogle in 1888-89, but could visit no hills from which triangulation could be carried out, except one near Thama itself, which the Sawbwa cleared for me. We remained at Thamagale, as some paddy fields in the valley west of Thama are erroneously called, till the 2nd of March, when we marched back to Mogaung in order to be ready to start for Wuntho, in case a force should be required to co-operate against that State from the north. Captain O'Donnell, Lieutenant Wilson, the Assistant Commissioner, and Lieutenant Whitehead, Staff Officer, and I, left the column on the 3rd and rode into Mogaung accompanied by the Sawbwa.

Before proceeding to Thama I availed myself of the opportunity of visiting Kamaing, as the Assistant Commissioner was going there to obtain information regarding Thama and the possibility of obtaining guides. I took a theodolite and plane-table and observed from two stations about 10 miles apart, hoping at a later date to be able to connect up with them, but this I was never able to do, and after staying there three days I returned to Mogaung. Lieutenant Gordon arrived at Kamaing the day before I left. I had left him with boats, taking up rations, to make a proper survey of the river, but they went too fast for him, and he was unable to do so. He subsequently went up the Endaw Chaung to Endawgyi, and surveyed the whole Chaung and immediate neighbourhood, after which he returned to Mogaung in time to accompany the force under Captain O'Donnell to Taungtonlon hill, near which, at a place called Payani, we were to meet the troops under Colonel Macgregor.

We started on this expedition on Monday, 9th March, *viâ* the Namyen valley and across the hills to Endawgyi, which we reached on the morning of 14th, and here we were met, on the 16th, by the river detachment which brought up rations in boats.

On our way to Endawgyi we heard that Mohnyin had been attacked, but that the military police there had beaten off the enemy, and two days before our arrival, some people,

probably from Wuntho, made a demonstration against Endawgyi, but their courage and enterprise oozed out when they saw the little well kept stockade on the knoll above the lake, and they passed on without attempting an assault.

The column remained three days at Endawgyi, and Lieutenant Gordon and I made use of this time to fix the latitude by star observations; we also measured a base and fixed some hills by plane-table intersection in the direction we were to go. From the far side of the lake opposite Lonton I got a ray to Taungtonlon, and this was useful subsequently.

We left Endawgyi on 17th March, and on 18th reached the Namsaag Chaung, on the banks of which we bivouacked, and on the 19th marched to Mansain on the same stream. This is a small Shan village of 10 houses, stockaded. We bivouacked for the night outside the village on the river bank, the people being very friendly. The next day we continued our march and met with no villages till we reached Penling, a small and strongly stockaded village on the south-eastern slopes of Taungtonlon hill on the 24th. We took the people quite by surprise, and as soon as they were assured we meant them no harm, they produced rice, fowls, etc., the women bringing the rice into camp as usual. The march between Mansain and this place was a trying one, though in most places the track was fairly good; we found traces of recent camps, no doubt those of the flying Wuntho Sawbwa, but met no one. On reaching Payani on 25th we found a small body of Colonel Macgregor's new Burma regiment (Gurkhas), and heard that he had gone on by another route to Endawgyi. We made ourselves more or less comfortable on the bank of the stream flowing past the village, and awaited orders. On the 29th, I rode to Na-aw to meet General Wolseley, and arranged with him that Lieutenant Gordon should accompany him to Kamaing and possibly to the Jade Mines, while I returned to Bhamo, to look after the party generally. From Na-aw I marched *viâ* Mansi, Banmauk, etc., to Katha, whence I went by steamer to Bhamo, which I reached on the 9th April.

On 14th April I removed the head-quarters to Mandalay, to which place the various detachments returned, the whole party having arrived by the 24th May. On the 27th May the head-quarters left for Rangoon and crossed over to Madras by the steamer of the 31st May, and reached recess quarters at Bangalore on the 6th June.

In conclusion, I would thank the various civil, military, and marine officers with whom the several members of the survey party have been brought in contact, for the ready assistance they have always given, and especially Mr. E. C. S. George, Deputy Commissioner of Bhamo, who has gone out of his way to promote the success of the various survey detachments. To the officers of the Intelligence Branch also my thanks are due.

EXPEDITION TO THE JADE MINES.

Extract from the Narrative Report of LIEUTENANT P. J. GORDON, S.C., *Season 1890-91.*

Leaving Payani on the 1st April, I accompanied General Wolseley and the Mogaung column to Endawgyi, which we reached on the 6th. The road lay for the most part through hilly country thickly wooded, the highest point reached being Loemaw hill (4,175 feet by aneroid). The few Kachin villages we passed were almost entirely deserted, but on being assured of friendly treatment many of the villagers who had been lurking in the jungle were induced to return and furnish supplies. At about 17 miles east of Payani, we came across a plateau, apparently of considerable extent, about three miles in breadth, and at an elevation of 2 800 feet. Here we noticed wild raspberries and tomatoes growing in great profusion, and the vegetation was generally of a less tropical character than that which we had hitherto come across. On the 5th a small party under Captain O'Donnell was detached to burn the village of the Sana Sawbwa (Loemaw)—one of the few Kachin chiefs in the district who had persistently refused to submit, and who had given shelter to most of the dacoits in the neighbourhood. We found the village entirely deserted, and the only signs of the opposition we were led to expect were numbers of freshly-felled trees blocking the approaches to the village. Next morning, after burning the village, we proceeded to Endawgyi.

At Endawgyi we met Colonel MacGregor's column, which had arrived that morning from Payani by a different route. The weather during the march had been close and hot, and the British troops suffered severely. Captain Bray, of the Intelligence Branch, died here of heat apoplexy shortly before our arrival. Arrangements were made at Endawgyi for an advance to the Jade Mines (where, it was reported, the ex-Sawbwa of Wuntho had fled), in two columns, one of which was to proceed by the Sakaw road, and the other by the direct road from Endawgyi. I arranged to accompany the former column, Colonel MacGregor, who commanded the other, promising to give me a sketch of the route taken by him.

Our column made a final start from Sakaw on the 13th of April, after many difficulties about carriage. The Panthay mule drivers, who had already stayed a longer time with the troops than they had agreed upon, absolutely refused to go further. They consented, however, to sell their mules, so, as no other alternative was possible, these were bought. As the Panthays load and drive their animals on a peculiar system of their own, the confusion for the first few days may be easily imagined. The road to the Jade Mines is a fairly good mule track, crossing low thickly-wooded ranges radiating from Loi Mawmay hill, where the Uru, Namkoung, and Namsong rivers have their source; this is the route chiefly used by Chinese traders on their way from Momein to the mines.

On the 16th of April we arrived at Sanka, a large Kachin village on the right bank of the Uru river, and the site of the original mines which are now exhausted. Instead of the stubborn resistance which we were told we should meet with, we were received in the most friendly manner by the inhabitants. The leading members of the Chinese community paid us a visit and expressed much satisfaction at our coming, which, they said, would enable them to carry on their trade with safety and allay the uneasiness which had occurred on the arrival of the ex-Sawbwa of Wuntho, who had fled in the direction of Yunan on hearing of the approach of the troops.

Next morning, we visited the mines (Taw Maw), which are situated on a plateau eight miles from Sanka, and 1,600 feet above the Uru valley.

The mines are all subject to the Kausi Sawbwa, who grants a concession to work them to a syndicate of Chinese capitalists, who employ Kachins and Burman Chins as workmen. The Sawbwa, the capitalists (who supply funds for the purchase of tools, and advances for food to the workmen), and the labourers divide the profits in the proportion of one-third share to each. In the working season (December to May) about 3,000 men assemble at the mines. Most of these leave at the end of May, and during the rainy season only 40 or 50 Kachins remain there. The workings are open quarries, and the stones are broken up by having water poured on them after having been subjected to great heat from wood fires. After this the pieces are taken out with crowbars. There are other mines in the neighbourhood, but those at Taw Maw are the largest and most important. Here there are about 120 houses and shops: rice is a good deal more expensive than it is down country, but candles, biscuits, matches, tinned milk, and other European goods are sold at little over Rangoon prices. There seems to be a strict miner's law to which all adhere, which regulates affairs at the mines. Theft is punished with death, drunkenness by the drunkard being tied up till he is sober; while in the case of murder, it is left to the relatives and friends of the murdered man to avenge his death. As might be supposed, with so severe a code, crime is scarce.

The best jade is exported to China *viâ* Bhamo, Mandalay, and Rangoon, and thence by sea to Canton, where the chief market for its sale is. Some is taken up the Taping river and *viâ* Momein, but the expense and difficulties of this route prevent its being generally used. A little of an inferior quality finds its way to Canton by the Chindwin and Rangoon. The jade is sold in pieces of different sizes, some of several maunds in weight, others small water-worn pebbles, in which form the best quality is usually found from the bed of the Uru river. The duty leviable on the stone (33⅓ per cent. on its value) is collected at Bhamo by a company, which leases from Government the right to collect it.

A durbar was held on the 17th April, at which most of the Sawbwas and most important inhabitants of the mines attended. On the following day I started for Kamaing with General Wolseley and arrived there next evening. All the European troops were withdrawn, and 100 Gurkha police and two mountain battery guns were left under Captain O'Donnell to form a post on the Uru river close to the village of Sanka. We arrived at Mogaung on the 22nd of April, and remained there until the 1st of May, when we left for Bhamo. At Senbo we found that the "Path-finder" which we had expected to meet there had been prevented from ascending the rapids on account of heavy floods in the Irrawaddy, so we had to do the first ten miles of the river in country boats.

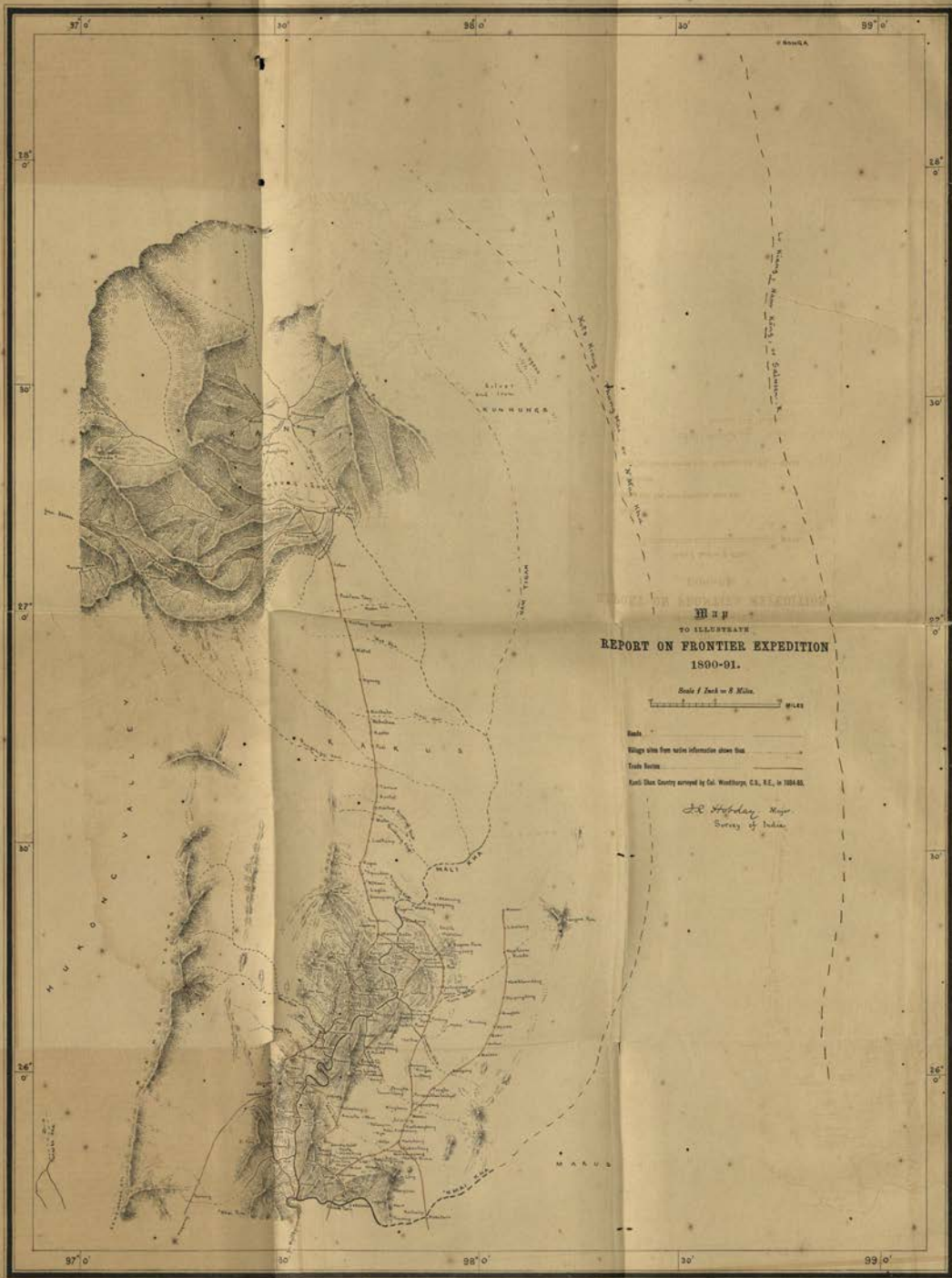
Owing to the thick haze which prevails all over Upper Burma during the month of April, and the rate at which the troops marched, I was only able, with the assistance of a soldier surveyor, to make a compass traverse of the routes gone over. The expedition did much to open the country and re-assure the inhabitants, and there ought to be no difficulty now in a survey party moving about the country with a small escort. Notwithstanding the lateness of the season, there was no sickness among my *khalásis* while in camp, although after we arrived in Mandalay several of them were attacked by fever.

EXPLORATIONS ON THE UPPER IRRAWADDY.

Report on the Survey Operations in the tracts lying to the north and north-east of the Bhamo District, by MAJOR J. R. HOBDAY, *S.C., Season 1890-91.*

Officers being required to accompany the special expeditions which were to proceed along the Yunan frontier under Lieutenants Daly and Eliott, it was arranged that I and Captain Renny-Tailyour should be attached to them, and that the latter with two sub-surveyors should go with the expedition along the southern frontier of Yunan under Lieutenant Daly, whilst I accompanied Lieutenant Eliott to explore the tracts to the north and north-east of the Bhamo districts. Sub-surveyor Sher Shah was attached to the expedition under Lieutenant Burton proceeding to the Kachin hills east of Bhamo. I arrived at Bhamo on the 8th December 1890. Our party consisted of Lieutenant Eliott, Assistant Commissioner (in charge), Lieutenant Blewitt, King's Royal Rifles, Intelligence Officer, and myself, with an escort of 70 Gurkhas of the military police of the Mogaung levy under a Native officer, whilst we had some 100 Panthay mules as transport animals. Sub-surveyor Mahomed Sayid, a soldier surveyor, and a Native doctor, also accompanied us.

We left Bhamo on the 22nd of December, arriving at Senbo above the first defile of the Irrawaddy on the same day in the Government steam launch *Buccaneer*, which was subsequently wrecked in the defile. After halting a day at Senbo we commenced our



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march northwards along the right bank of the Irrawaddy, a few rifles being detached to escort some half dozen boats, which were engaged to carry up the bulk of our rations by river. I went with the boats in the hope of carrying on a triangulation, whilst sub-surveyor Mahomed Sayid traversed the route followed by the column from Senbo to Hokat, about 36 miles by road, where we all met again on the 26th December. From Hokat I made a trip to Kayon Taung, a hill about 5 miles to the south-west, but the weather was unfortunately cloudy and unfavourable for observations. On the 28th we resumed our march, when I sent the sub-surveyor with the boats, and kept with the column myself It soon became evident that triangulation was out of the question, for the track lay along flat country covered with dense primeval forest, through which we had to cut a way for the mules; a wall of stupendous trees, bamboos, and creepers on either side of the path, shutting out all view of the surrounding country. With the exception of a tract of open country in the neighbourhood of the village of Myitkyina, our track led through this dense forest up to Pumlum Pum, the most northern point reached by us.

We arrived at Myitkyina on the 31st December, and reached the confluence of the two main branches of the Irrawaddy on the 5th January, the boats coming in a day after, having been delayed by the rapids near the village of Lapè. The water was near its lowest, and running very strong in both the eastern and western branches of the Irrawaddy, which are known by the Kachins respectively as the 'Nmaikha and Malikha or the "Bad River" and the "Good River", and amongst the Burmese as the Myit Ngè and "Myit Gyi," or the "Small River" and the "Big River." Although we proved beyond doubt that the eastern branch is the larger of the two, it is not navigable for boats at low water for any distance owing to a succession of formidable rapids that exist about 6 to 8 miles from the confluence, hence its name "Bad River" or "Small River." On the other hand, the Malikha is navigable for boats for some distance, certainly as far as Sawan, and probably much further.

We determined to send back the boats and surplus rations from here to Myitkyina under an escort of 20 rifles; so taking about six weeks' supplies on the mules we continued our march northwards up the right bank of the Malikha. The path now commenced to enter the hills. After ascending and descending these, and crossing several tributaries, which rise in the Kamôn Taung and flow into the Malikha from the west, we at length reached the summit of a hill known as Pumlum Pum, in latitude 26° 15″ or 7 marches north of the confluence. Here we suddenly found ourselves in a densely populated locality, and the inhabitants far from polite or friendly. We halted a day to attempt to parley and come to some understanding with them, but signally failed; in fact matters were becoming rather serious, for they refused to come into our camp, abused and insulted our messengers, strongly objected to their country being surveyed, and commenced sending armed men in various directions to warn the tribes to oppose us if we advanced. With our small escort of 50 rifles, and the long string of mules, stretching for a mile along the road, it was hardly prudent to attempt to force our way further under the circumstances, so to avoid collision there was no option left but to retrace our steps. A few shots were fired by them at some distance behind our rear guard, which presumably signified bravado at having turned us back, or else anger at our having eluded the trap they intended to lay for us on ahead.

Fortunately from Pumlum Pum a fine view was obtained, and the valley of the Malikha could be traced almost as far as the Kanti Shan country (Meung Lang), which was visited by Woodthorpe and Macgregor in 1884-85; the intervening hills being quite insignificant. To the west rose the Kamôn Taung, running north and south, apparently in an unbroken chain of peaks from 7,000 to 8,000 feet in altitude, forming the watershed between the Malikha and Hukong valleys, and far away to the north were hills of 10,000 feet elevation and upwards, whilst to the north, north-east, and east snow was lying in patches on the higher ranges. To the east five clusters of hills, known as Sañgaw Pum, form the eastern flank of the Malikha basin. In every direction the hill slopes were studded with numerous villages and clearings for cultivation. The next march would have brought us to Marao Saṭa, a trade centre, where there were said to be some 100 Chinamen trading in India-rubber. Here also salt is obtained by boiling the water which contains it in solution in iron pans, but the supply is not in sufficient quantity to meet the demand.

From Pumwai we returned by another route east to Sabaw, and then south along the right bank of the Malikha to Kwitao, where we crossed to the opposite bank, and struck the 'Nmaikha at the Lekennoi ferry, some 20 miles above the confluence. The crossing at Kwitao is decidedly bad, the current being very swift, and no boats available. Bamboo rafts have to be constructed, and a Berthon boat which I had, proved most invaluable At the Lekennoi ferry we found a large dug-out, and the 'Nmaikha running very sluggishly through deep pools. I sounded the depth and obtained a maximum of 93 feet. From this point we returned by the road followed by "Alaga," a Burman who was sent up to explore these regions by Colonel Sandeman in 1879, to Maingna, a Burmese Shan village on the left bank of the Irrawaddy.

After replenishing our supplies we made a fresh start from Maingna on the 5th February towards the 'Nmaikha valley; but owing to the opposition shown by the Sadan tribe of Kachins at Kwitu and Lakapyang (three marches from Maingna), and the fact of there being no mule tracks up the 'Nmaikha beyond 'Nsentaru, two marches above Lakapyang, we were compelled to give up all idea of penetrating in that direction. There was an absence of all information about the valley of the 'Nmaikha and the head-quarters of that river. "Nobody goes there" was the inevitable reply we received to our

enquiries, and we could only elicit vague stories about the Marus or dog-eating Kachins, the Yawyins, and other wild tribes that inhabit those regions.

We now practically know the basin of the Malikha, but all ideas of the valley of the 'Nmaikha or eastern branch still remain involved in mere speculation. 'I am inclined to concur with the conclusions arrived at by the late Sir H. Yule in his introduction to Gill's "River of Golden Sand." The 'Nmaikha has probably not a much longer course than the Malikha, judging from appearances at the confluence, though I admit that appearances in such cases are often deceptive. The Kuts Kiang, Phungmai, and 'Nmaikha are probably identical, and what is known as the Lu Kiang near Bonga is probably the Salween or Namkong of the Shan States, flowing, as we know it, in a very restricted basin, though I should hardly assign its source to be at so great a distance in Tibet.

From Lakapyang we turned southwards to explore the country along the Yunan frontier down to the Taping river. Marching along the outer ranges of hills we at length reached the village of Kazu on the Nantabet or Namtabak which rises in the Yunan plateau. We then fortunately succeeded in pushing our way up the higher ranges, eastwards for about three marches, as far as the village of Paotaw close to the border. The following day Eliott and I reconnoitred a few miles beyond the village of Chinglum, where we obtained a fine view of the junction of the Nantabet and Meungka-khas, and of their course as they flow off the plateau. On our return to Kazu we travelled north-west, and completed our second trip at Waingmaw on the Irrawaddy on the 25th February. From Waingmaw we moved southwards and reached Talawgyi in four marches, crossing the Nantabet and Nam-mali Chaungs *en route*. From Talawgyi we started eastwards on our third trip on the 9th March, pushed into the hills as far as Ning-Chang *vid* Kantaoyang, and then southwards to Namsangyang and Manmaeu, a Burmese Shan village on the Molé Chaung. Crossing this river we again ascended the hills to Pumpien, and finally returned to Talawgyi on the 26th March. From temporary indisposition I was now incapacitated from riding or walking, and as the work was practically finished, and the party was only going to march down to the Taping along a flat and uninteresting country which the sub-surveyor could map, I took a boat to Senbo on the 30th March, arriving there the same day, and reached Bhamo the following day in the Government launch *Pirate*. The remainder of the party returned to Bhamo about the 13th April.

The total area mapped was about 4,300 square miles on the scale of 4 miles to the inch. The whole must be treated as a reconnaissance, for triangulation and survey in detail was impossible, as we were marching for weeks together often with a wall of forest on either side of the path. As we were advancing however from south to north along a meridian, the work was well checked by careful observations for latitude at every other camp, whilst points in our rear always assisted us in determining our longitudes.

To the above area has to be added some 1,000 square miles done by sub-surveyor Sher Shah, who accompanied Lieutenant Burton's force into the Kachin hills east of Bhamo. This work joins on to mine of previous years to the south, and thus we now possess a fair knowledge of the Yunan frontier between the 24th and 26th parallels of latitude.

With regard to any future explorations in these parts, an expedition starting from Kamaing and marching up the Namkong valley to the amber mines and Meungkwom in the Hukong valley might be able to work its way across to Kanti, and thence south to Sawan on the Malikha, where supplies could be sent up by boats to meet it. From this point a fresh start could be made eastwards towards the 'Nmaikha, and finally returning to 'Nsentaru The escort should not be less than 150 men. After we have visited the Kanti country and entered into friendly relations with its Shan Sawbwas, as well as subjugated the Kachin tribes intervening between Kanti and our present borders in Burma, it will be found that a party, or a single native explorer, starting from Kanti as a base and working eastwards would have the best chance of solving the question regarding the sources of the Irrawaddy, as well as the identity of the Lu and Salween rivers.

EASTERN FRONTIER OF NORTHERN SHAN STATES.

Report on the Survey Operations in the NORTHERN SHAN STATES, *by* CAPTAIN T. F. B. RENNY-TAILYOUR, R.E., *Season 1890-91.*

On the 25th of November 1890 I left Mandalay, accompanied by sub-surveyors Bapu Jadu and Ali Nawaz Khan, and reached Lashio, the head-quarters of the Superintendent of Northern Shan States, on the 14th December.

It had been arranged to send out two expeditions from Lashio. The objects of the one under Lieutenant Daly, the Superintendent of the Northern Shan States, were to visit the capitals of the western Mangleun, east Mangleun, Meunglem, and Keng-hung States, and to ascertain, as far as possible, the relations between these and other States with Burma and with China. The objects of the other expedition under Mr. Saunders were first to visit and find out as much as possible about the Kachins near the Chinese frontier, north of the North Theinni State, and then in the Taungbaing State, to visit every village and obtain full particulars of the number of people, houses, cattle, etc., in each. The geography of the country covered to be mapped in both instances.

It was arranged that I should go with Lieutenant Daly's party, taking sub-surveyor Ali Nawaz with me, while sub-surveyor Bapu Jadu should accompany Mr. Saunders' party; unfortunately Bapu Jadu was suffering from bad inflammation of the eyes, and he was unable to start with Mr. Saunders, but he joined the party when they had got into the Taungbaing State. However Lieutenant Prowse of the Intelligence Branch with a military surveyor accompanied the party, and as they could nearly always see some of the peaks fixed by my triangulation in the beginning of 1889, a fairly accurate sketch of the route was made. During my stay at Lashio I observed from two of my old hill stations and took some star observations for azimuth. On the 21st December I started from Lashio with Ali Nawaz, the other members of our party being Lieutenant Daly who was in charge, Mr. Warry of the Chinese Consular service, and Captain Burrows of the Intelligence Branch; the remainder consisting of 56 Military Police (Gurkhas), 50 followers, and about 30 Panthay muleteers with 120 mules.

We reached Meungyaw on the 23rd December, stopped over Christmas Day and starting again on the 26th, reached Manmak on the following day. This place is the capital of the Manmak sub-division of north Theinni, and is situated in a fine broad valley which unfortunately, owing to Kachin raids, had been almost entirely deserted. We left Manmak on the 31st December and arrived at Nawngleng on the 1st January. This place, at an elevation of about 5,400 feet, is the capital of a sub-division of south Theinni, called Loimaw; the people are mostly Chinese, and grow a large amount of opium; a number of Chinese and Panthay caravans passing through here on purpose to get the opium to take with them to Burma. We halted at Nawngleng for two days, and I was able to ascend and partially clear a peak of Loimaw, called Loilan, about 7,300 feet elevation. The weather was unfortunately very cloudy, and a good view was not obtainable.

We started again on the 4th January and reached Nawng-hpa on the 5th. While here we were met by representatives from west Mangleun and east Mangleun States, the latter bringing some presents of fruit, etc., including two dried squirrels; these being regarded by the Was as a special token of good faith and friendship. Leaving Nawng-hpa on the 8th January we crossed the Salween river (Namkong) at Takwi-hpong: the descent to the river is in places steep, the banks are very rocky and the current extremely rapid; the width is from 90 to 100 yards, and the depth from 60 to 70 feet in the centre. The elevation of the Salween here is about 1,350 feet, but I was only able to get the height approximately from barometer readings, as the banks of the river were very steep and jungly, and I could not observe to any of my triangulation points. Our baggage and mules took nearly twelve hours to cross. On the 9th January we reached Man-hpang, a large village on the top of a hill, and the capital of a small State tributary to east Mangleun, called Mot-hai. The Sawbwa and most of the people here are Was; they are, however, far more civilized than their kinsfolk further east. During the two days we halted at Man-hpang I went out to a hill to the east and formed a station, while Ali Nawaz took out his plane-table to the north.

Leaving Man-hpang on the 12th January, we re-crossed the Salween river and passing through Nawng-hpa on the 15th reached Nalau, which, although it is the capital of the West Mangleun State, is only an ordinary sized village situated in a small valley. The Sawbwa had run away before we arrived, and, although we waited for four days, he was too afraid to come in. The halt, however, enabled me to form two stations on neighbouring hills and to take some star observations for azimuth in camp. We started from Nalau on the 20th January and crossed the Salween river at the Hsupket ferry. The crossing here was much easier than at Takwi-hpong, for, although the river itself was much the same, the banks were less rocky and not nearly so steep. I was again unable to obtain the exact height of the river, but the barometers made it about 1,250 feet or 100 feet below our last crossing. Along the banks of the Salween here, great quantities of betel leaf creeper are found and people come from very long distances to get them. We also passed through several orange groves near the river. Marching on daily until the 26th January we arrived at Pangyang. This place used to be the capital of east Mangleun, but the Sawbwa moved to Takeut about ten years ago, making that his capital. As Takeut is situated on a sharp ridge, without any particularly good camping ground in the vicinity, and is also about 8 miles off the main road along which we were going, it was considered advisable to halt at Pangyang, and the Sawbwa came here to see us.

Pangyang is at an elevation of 4,650 feet, and is situated on a flat topped spur running out from the Pemeung range. This range extends the whole way from Man-hpang to Pangyang, and has a height in one place of nearly 7,000 feet. We halted seven days at Pangyang, and during this time I made a trip with Ali Nawaz of about 20 miles along the Pemeung range. I formed two stations on prominent peaks, and a lot of country was mapped on the plane table. The people at Pangyang are a very civilized species of Was, but prefer to be called Shans; the Sawbwa was a pleasant, rough mannered old man, and appeared very glad to see us.

On the 3rd February we marched to Katmaw, halting the next day so as to pay the Sawbwa a visit at his palace at Takeut about 8 miles off. Round Katmaw there are several mines which formerly used to yield silver, but now they are only worked for lead. Starting again on the 5th February we reached Meung-nga on the 10th. Meung-nga is situated on the left bank of the Namkha, and just inside Meunglem State; the Namkha (which runs here at an elevation of about 1,700 feet, and was only just fordable) being the boundary for a greater part of its course between the east Mangleun

and Meunglem States. These two States had been fighting against each other at Meung-nga for two months, but on our approach they made peace. During the fighting only about 20 men were killed and wounded and about 15 villages were burnt. All the villages within 10 or 12 miles of Meung-nga had been deserted since the fighting commenced, but the villagers returned within a few days of our arrival. We halted at Meung-nga a couple of days, and as my triangulation was getting shaky owing to the hazy weather, I measured a base and took observations for azimuth. I also ascended a hill and formed a station, but had the greatest difficulty in getting any of the warriors to guide me, eventually having to pay them three rupees each: they were very much afraid of tigers, which they said had carried off people on several occasions during the previous three or four months. We left Meung-nga on the 13th February, halted for the night at Meungma, and arrived at Meunglem, the capital of the State, on the 15th. Two miles from the town we were met by a party of officials who read us an address of welcome, and a mile further on we were received by the Sawbwa and all his ministers. The Sawbwa who had a pig-tail, wore a Chinese dress and is very Chinese in appearance, but curiously can only speak Shan.

The town of Meunglem is large, and is situated on one side of a small paddy plain, at an elevation of about 3,300 feet. Halting four days here, we were enabled to survey a good deal of country in the vicinity. The latitude and longitude of Meunglem are given by M. Garnier, and probably one of the French Commission had been here; the latitude was almost identical with mine, but the longitude was about ten minutes too great. The Meunglem State is large, but at present the Sawbwa, who is a Lem, has very little influence beyond the Shan and Lem communities who occupy the low country. The Las, Was, and Muhseus who inhabit the hilly country, which comprises at least two-thirds of the State, consider themselves more or less independent, and cause a good deal of trouble. The Chinese have also during the last few years been encroaching on the north of the State. Leaving Meunglem on the 20th February we marched through hilly and very sparsely populated country, crossed the Namlam on the 26th, halted a day at Meungmang, and reached Meungse on the 1st March.

The Nam Lam for a greater part of its course marks the boundary between the Meunglem and Kenghung States: where we crossed it the banks were very rocky and the river unfordable, the men and baggage having to cross over a very rickety bamboo bridge, the animals swimming. The town of Meungse contains between one and two thousand houses, and is situated on a knoll in the middle of a large circular paddy plain, from seven to ten miles in diameter, and at about 4,000 feet elevation. When we arrived there was a civil war going on between the Meungse Myoza and the Kenghung Sawbwa, the centre of hosilities being about three miles off. The fighting had been going on for several months in the usual Shan style. Meungse was used as a city of refuge by the inhabitants of the surrounding villages, and at night probably contained nearly 15,000 people and 10,000 head of cattle.

We halted at Meungse three days, during which time Lieutenant Daly was in communication with both sides, who seemed thoroughly sick of fighting, but neither cared to be the first to suggest stopping. On the 5th March we marched to where they were fighting, and Daly pulled down and burnt all their stockades, sending the opposing forces to their own districts. We arrived at Meunghai on the 6th and found the Kenghung Sawbwa had taken up his abode here temporarily so as to superintend the fighting. The Sawbwa was a young man, but appeared to be very weak minded, and, from all accounts, entirely in the hands of his wife and a few others. He seemed glad to see us and to hear that we had stopped the fighting.

While at Meunghai we were joined by the main body of the Kyaington-Chiengmai mission under Mr. Scott. Mr. Kennedy, who was in charge of the survey with the mission, was not with them, having gone by an alternative route to Kengtung (Kyaing-ton). There was, however, a military surveyor, and his road sketch will be of use for the map.

Leaving Mr. Scott's party at Meunghai, we started on the 10th of March and arrived at Kenghung, the capital of the State, on the 12th. The Kenghung State is very large, and divided into two fairly equal parts by the Cambodia river (Mékong). The capital is a very wretched town, considering the size of the State, containing only two or three hundred houses, and situated on a small hill on the right bank of the Cambodia. The river for two or three miles above Kenghung widens out considerably, and in the rains is probably a couple of miles in width; it has here an elevation of about 1,950 feet.

The haze, which since leaving Nalau had been gradually thickening, was now like pea soup, and four or five miles was about the limit we could see. My triangulation was pretty good up to a little beyond Meung-nga, but there I had a gap of about 10 miles to Meunglem. At Meunglem I took the plane table values and commenced anew from a measured base and an observed azimuth. I ran this triangulation under difficulties to a little beyond Meunghai, measuring bases and observing for azimuth at Meungmang, Meungse, and Meunghai; this rough triangulation, although not accurately connected with the original series, gave points for the plane tabling; and as Ali Nawaz ran a rope traverse along the road, the position we obtained for Kenghung is probably very nearly correct. M. Garnier had been to Kenghung and had made very careful observations for latitude and longitude, having with him besides other instruments two or three first-rate chronometers. His position of Kenghung agrees within about a mile with mine, which is a most satisfactory connection. On the return from Kenghung the haze continued, and I was

unable to do any more triangulation; and as we were making longish marches, very little, besides a simple road traverse, was possible.

We left Kenghung on the 15th of March, and proceeding by a new route arrived at Meungma in Kengtung State on the 22nd, having re-crossed the Namlam at Talaw; this river was easily forded by our party. We were joined at Meunghun by Mr. Scott's party and they marched with us to Meungma. From here our roads separated and we turned northwards, cutting into our old route at Meungma in Meunglem State on the 28th March, having crossed the boundary between the Kengtung and Meunglem States the same morning. On the 30th March we arrived at Pang-hsaug, a village on the right bank of the Namkha opposite to Meung-nga, and here found that the inhabitants had all returned to their villages.

Halting a day we left Pang-hsang on the 1st April by a new route, running almost due north, and from here to Panglong we passed through a succession of small States and circles, part of the route being through the western corner of the celebrated wild Wa country. The wild Was we met were supposed not to be quite so bad as the ones further to the east, but were quite repulsive enough in appearance, wearing little or no clothes, and being coated with dirt. At the entrances to their villages there were generally from 10 to 20 human skulls stuck up on posts beside the road. On certain occasions, such as sowing time, harvest time, the prevalance of a disease, etc., their spirits whom they worship, require a human head to be offered to them so as to bring luck. Most of these heads they get in fights or by purchase, but when very hard up they make a head-hunting raid and prefer getting a Lem's head to any other. In consequence some of the roads in Meunglem state and part of the main road we traversed are considered unsafe at certain seasons, and the Lems will only travel along them in large parties. The wildest Was are also supposed to be cannibals.

On the 15th we passed through Pangkwawn, the capital of the Sumu State, the people of which are Las. Here we only just escaped being fired upon, the villagers running out and pointing their guns at us, but fortunately some Panthays who had been sent out from Panglong to meet us had just arrived, and they rushed in front and managed to calm down the villagers sufficiently; eventually we found their fears were all owing to a misunderstanding of the objects of our visit, and that they thought we intended to arrest the Sawbwa. We arrived at Panglong on the 7th April, and were received in great style by the whole male population. Panglong, with probably 400 or 500 houses, is situated at an elevation of about 4,700 feet in a kind of saucer, with small volcanic looking peaks all round. It is a particularly cool place considering its elevation, and in winter there are severe frosts and often heavy falls of snow.

The inhabitants of Panglong are all Panthays, and represent the great majority of the remnant who escaped the vengeance of the Chinese after the great Panthay rebellion in Yunan, and are consequently deadly enemies of the Chinese. They seem a most excellent people and were delighted to see us, doing all they could to make us comfortable. The Panthays are all Mahomedans, and several of the old men had actually visited Mecca. Their principal cultivation is opium, and they breed mules for pack purposes, which have come in most usefully as transport for the numerous expeditions since we took over Upper Burma. While at Pangyang we had a very severe thunderstorm accompanied by a heavy shower of hail; our tents were nearly blown away, and it made us very uncomfortable for several hours. From the date of our arrival at Panglong until we reached Mandalay there were showers of rain almost every day, which, although very unpleasant for marching in, helped to clear away part of the haze and made it possible to plane table a fair amount of country on each side of the road.

Leaving Panglong on the 20th April, we crossed the Namting on the 21st and encamped at Nam-hu on the right bank; the river was not fordable. We were now back again in North Theinni State and met a convoy of rations, having hit off the time exactly, only one day's rations remaining from our original supply.

Nam-hu is about 5 miles from Kunlong ferry on the Salween; but as we wished to visit Tunyeo, the capital of the Kokang sub-division of north Theinni, we turned away from the Salween and arrived at Tunyeo on the 24th. The population in Kokang is mostly Chinese Shan, and at Tunyeo the Myoza, and most of the people could only speak Chinese; they seem to be a good lot, and produce much better fighting-men than the ordinary Shans. Leaving Tunyeo on the 26th April we crossed the Salween at an elevation of a little under 1,500 feet on the 27th at Tanamsom and arrived at Theinni on the 4th of May, having joined the Meungse-Theinni road at Yungmaw. Lashio was reached on the 7th and Mandalay on the 22nd May. At Lashio I found sub-surveyor Bapu Jadu waiting for me. He had been out with Mr. Saunders since the end of January, and had done very good work, having surveyed the whole of the Taungbaing State. Mr. Saunders spoke very highly of his energy and zeal. Sub-surveyor Ali Nawaz had also worked well with me, and, although on several occasions suffering from slight fever, he never stopped work.

During the season I confined my attention almost entirely to triangulation, attempting to keep Ali Nawaz supplied with points for his detail survey. In all I observed from about 50 stations and camps and worked out nearly 200 intersected points. The area surveyed was approximately 5,250 square miles, including about 1,250 square miles executed by Bapu Jadu. I must record my very best thanks to Lieutenant Daly, who throughout our tour did his utmost to ensure the survey work being successful, and took the greatest trouble to get me the correct spelling of all names.

KYAINGTON-CHIENGMAI FRONTIER MISSION.

Report on the Survey Operations with the KYAINGTON-CHIENGMAI MISSION, *by* MR J. M. KENNEDY, *Assistant Surveyor, Season 1890-91.*

Early in November, having previously received orders to join the Kyaington-Chiengmai frontier mission, I placed myself under the orders of Captain Fulton at Rangoon, by whom I was directed to proceed to Meiktila road station and to report myself to Dr. Gray who had gone on in advance. I was accompanied by sub-surveyors Mahomed Hussein and Abdul Rahim. The necessary transport having been collected there, the party moved on to Fort Stedman by double stages along the main road, a good fair-weather track.

A halt was made at Fort Stedman for a day or two to arrange for an escort from the post, and the party then marched on by well known routes over ground already surveyed to Moné, the easternmost post in the Shan States, and thence to Möngtun, where Mr. Archer, who had come up from Zimmé (Chiengmai) to take charge of the mission, was awaiting our arrival.

From Möngtun a route traverse had been run the previous season during the course of the Anglo-Siamese Boundary Commission, by Captain Jackson north-eastward to Maingthat. I therefore struck off the road to re-visit the last of Mr. Ogle's stations of observation during the same mission, Loi Pakulin, and to this point, though I had two guides from Möngtun who had accompanied Mr. Ogle there the previous year, I was obliged to find my own way, as the guides lost themselves before midday in the first day's climb. The survey party reached the hill top at noon next day, and after finishing the necessary observations and waiting two hours more for the guides to come up, began the descent to Tongtun to the north. It had been arranged that the main body would await us here, but the guides again delayed, and we found, on our arrival on the third day at Tongtun, that the party had moved on. Having no supplies for the day we were obliged to follow immediately with our tired coolies, and after a severe march over a pass 3,000 feet high came up with the main party in camp at 7 P.M., having this day marched without food or rest for 13 hours.

From Maingthat, the next place where a halt was made, one of the sub-surveyors was sent into the hills to the south, the other directed south-eastward to Hongluk, where he was to turn down by a selected route, south-west and west, to Wiengkhé, a village (found afterwards to be deserted) at the north-east end of the Muang Fang valley. I went north-east up the Mekôk, and returned to rejoin the main body before the party moved; the sub-surveyor sent southwards, came into camp at the same time. Crossing the Mekôk on the 31st December, we travelled for the next week down the east bank of the Mekôk at the rate of three or four miles a day, having to clear a track with the help of coolies and sepoys, and sometimes to fell heavy timber to open camping places. From Hwéha, a village one day's march above Wiengkhé, I ascended to Loi Pahampup, the highest of the hills west of the Mekôk. I was delayed here by sickness and by the greater part of my men losing their way, having been misdirected by my Shan interpreter: when they rejoined me at Muang Fang they were on the verge of starvation. This was not the last freak of my intelligent interpreter, for I found him throughout the season fiendishly ingenious in upsetting my arrangements for work, and I should have been glad to be rid of him at some expense to myself; he showed throughout great willingness to do everything but his proper work. Muang Fang is a small decaying town with the remains of a palisaded wall; on the east face there is a daily market poorly furnished and scantily attended.

At Muang Fang we found a messenger from Mr. Archer, and as directed by him, marched through to Wiengkhé, another distressing march of 18 miles over swampy ground, most of us being still ill. We came into camp late at night and moved next day; one of the sub-surveyors who had previously rejoined the main party being sent to Kyainghai down the Mekok in boats. This man re-appeared later on, clad in various coloured lengths of towel stuff and reported that he had lost all his belongings by the wreck of one of the boats. Accompanied by the other sub-surveyor, Mahomed Hussein, I went across the hills to Hongluk, while Mr. Archer's party took the longer but easier route previously traversed by Mahomed Hussein. I had attempted to get to the head of the Mekham, a stream which Mr. Archer wished to have accurately laid down, but having failed in this, Mahomed Hussein was sent back with men from Hongluk, and with some trouble made his way there and rejoined us a week later.

To the south-east of the Hongluk plain, beyond some low hills, is the large town of Kyaingsen, which, with Muang Fang and the small post near Takhileik, are the frontier posts of Siam in this direction. The line of the Mekong valley railway through Kyainghai has been surveyed as far as Kyaingsen; and there would be no difficulty in the further extension of the line through Hongluk and Meunglen to the crossing of the Mekong at Kyanglap and following the route taken by the mission to Mongsin (Möungsin).

Two days' journey south-west of Hongluk, in the Mesolong, a tributary of the Mekham or (Gold River), gold is found in the sands of the stream, and the high hills west of the Mekham-Takhiliek road appear to be worth prospecting. There is gold too in the upper course of the Mesai stream; and this is worked by the hill people during the months when they are not required to labour in the fields.

The party next proceeded *viâ* Meunglen to the Mekong at Kyanglap. Sub-surveyor Abdul Rahim, who had been sent on previously from Hongluk to Kyaingsen, crossed and re-crossed the river above Kyaingsen and rejoined the party at Meunglen. The crossing of

the Mekong detained the party four days, the work being delayed by a heavy and continuous rain.

From Kyanglap, Mahomed Hussein was sent back *viâ* Meunglen to Kyaington and ordered to await the arrival of the party there; Abdul Rahim was sent northward to Möngyu and directed to turn across the hills from Möngyu eastward to Möngsin, while I accompanied the main body up the Namma valley. I made two excursions into the hills south of the Namma, one from Ban Mon, and another longer trip from Möngsin: these hills were covered with poppies: opium and some dye-stuff being grown largely here.

Möngsin (Meungsin) is a large village enclosed by a low wall and ditch, which stands in the middle of a cultivated plain four or five miles square, the east, south, and west sides being shut in by high hills which are broken by a gorge on the south through which the road up the Namma valley enters; on the north and north-east are low broken hills. The ascent of about 700 feet from the Mekong at Kyanglap to the Möngsin valley is gradual and almost imperceptible.

From Möngsin Mr. Archer and the other officers with the mission went north-eastward, while I and a sub-surveyor started for Kyaington, each going by a different route to Möngyu, where we met and proceeded together to Kyaington. We arrived four or five days before the remaining body of the mission.

The country between Möngsin and Kyaington, though difficult to move about in, is fairly well populated. Small villages exist along the Mekong, about a day's journey apart from one another: the valleys of the smaller streams where they open out are almost entirely under cultivation. The clearings on the hills are large and numerous, and the hill villages are densely packed, several families or numerous members of a family apparently occupying the same hut. The names of these hill villages are changeable, the places being called after the headmen at the time being.

I could not utilise as I wished, the work of the military surveyors under Captain Fulton. Their route traverses were plotted on a large scale, and my own time during the few halts made while I was with the main body of the expedition, was fully taken up in putting together the detached pieces of work brought in from time to time by the sub-surveyors, and in copying the entire map. I was unable to make any copies or reductions of any of the military work, except a traverse round from Möngsin to Kyaington, which connected the work of this party with that done by Captain Renny-Tailyour on the north. The party left Kyaington for the return march on Easter Sunday and arrived at Rangoon early in May 1891.

DRAWING OFFICE, CALCUTTA.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILATION.

Statement showing the work performed during the year 1890-91.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
Atlas of India.			
Sheets Nos. 9 S. E., 41 S. W., 21 S. E., 22 N. E., 35 S. W., 36 N. W., 39 S. W., 42 N. E., 42 S. E., 51 S. W., 52 S. E., 57 N. W., 59 N. W., 78 N. W., 78 S. W., 88 S. E., 104 N. W., 145 N. E., and 145 S. E.	19	4	Additions to names and outline for engraving.
Sheets Nos. 22 N. E., 25 S. E., 26 N. E., 36 N. W., 36 S. W., 49 S. W., 50 N. W., 59 S. W., 60 S. W., 60 S. E., and 61 N. W.	11	4	Hills brush-shaded for engraving.
Sheets Nos. 15 N. E., 15 N. W., 35 N. W., 35 N. E., 47 N. W., 47 N. E., 47 S. W., 47 S. E., 48 N. W., 48 N. E., 48 S. W., 48 S. E., 49 S. E., 79 N. W., 86 S. W., 89 N. W., 90 N. W., 90 N. E., 90 S. E., 91 N. E., 104 N. E., 105 S. E., 124 S. E., 125 N. E., 129 N. E., 129 S. E., 130 N. W., 130 N. E., 130 S. W., and 130 S. E.	30	4	Additions to railways, canals, and changes in boundaries.
Sheets Nos. 68, 106, and 115	3	4	Ditto ditto.
General Maps.			
India (Engraved)	6	32	Additions to date.
Do. do. (Railway)	1	96	Ditto.
Do. do.	1	128	A new compilation in progress.
Do. do.	1	256	Orthography revised.
Do. (Lithographed)	6	32	3rd edition, additions to date.
Do. do. (Railway)	4	48	Additions to date.
Do. do.	2	64	Ditto.
Burma and adjacent countries	2	32	2nd edition, completed.
Provincial Maps.			
Burma (Upper)	1	16	A new compilation in progress.
Assam (Engraved)	1	16	Additions to Aka and Daphla hills and Kubo Valley.
Do. (Lithographed)	1	16	
Punjab (Engraved)	2	16	Additions to railways.
Central Provinces (Engraved)	2	16	Ditto
Punjab (Skeleton)	1	16	Ditto.
Bengal, Behar, and Orissa	2	16	Ditto.
Do. do. do.	2	16	A new compilation in progress.
Do. do. do. (Lithographed)	2	16	Additions to railways.
Burma and Assam (Skeleton)	1	32	Ditto.
Central Provinces	1	32	Ditto and corrections to boundaries.
N.-W. Provinces and Oudh	1	32	Ditto ditto.
Assam (2 copies)	1	48	Corrected to date.
Divisional Maps.			
Presidency	2	8	Additions to date.
Chota Nagpur	8	4	In progress for reduction to ½ scale.
Orissa and Tributary States	4	4	Ditto.
Chittagong	2	8	Completed.
Gorakhpur and Benares	1	4	Additions to date.
Rajshahi	1	8	Completed.
District Maps.			
Burdwan Durbhunga Gya Monghyr Moorshedabad Noakholly Patna Rajshahi Shahabad Naga Hills	10	4	Additions to railways, roads, canals, and corrections to boundaries.
Akyab	1	8	Ditto.

DRAWING OFFICE, CALCUTTA.

SECTION I—*continued.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
Standard Maps.		Miles per inch.	
Berar Circle.			
Sheets (Nos. 6–12) . . .	1	1	Roads inserted.
BHOPAL AND MALWA—			
Sheets Nos. 11, 13, 15, 17, 18, and 48	6	1	Additions to roads.
CENTRAL PROVINCES—			
Sheets Nos. 31, and 32 . .	2	1	Completed to margin.
CENTRAL INDIA AGENCY AND RAJPUTANA—			
Sheets Nos. 254, 283, 368, 379, 389, 390, 391, 392, 468, 477, and 479	11	1	Ditto.
Sheets Nos. 335, 396, 397, 408, 409, 410, 421, 429, 430, 441, 447, 449, 450, 473, 474, 478, 480, 481, 482, and 483 .	20	1	In progress.
GUJARAT SURVEY—			
Sheets Nos. 77, 78, and 79 .	3	1	Railways inserted.
GWALIOR AND CENTRAL INDIA AGENCY—			
Sheets Nos. 3(*a*), 4(*a*), 9(*a*), 10(*a*), 2(*b*), 4(*b*), and 368 . .	7	1	Roads inserted.
KHASI AND JAINTIA HILLS—			
Sheets Nos. 21 and 22 . .	2	2	Additions to boundaries.
Sheets Nos. 18, 20, and 23 .	3	1	Ditto.
LOWER PROVINCES—			
Sheets Nos. 1, 2, 3, and 6 .	4	1	Completed up to margin.
MADRAS—			
Sheets Nos. 32, 33, 51, and 52	4	1	Compilation from 2-inch settlement maps in progress.
Sheets Nos. 150, 151, and 152 .	3	1	In progress.
N.-W. PROVINCES AND OUDH—			
Sheets Nos. 12(*a*) 26, and 43 .	3	1	Completed to margin.
PUNJAB—			
Sheets Nos. 262, 280, and 325	3	1	Ditto.
UPPER BURMA (NORTH-EAST FRONTIER SERIES)—			
Sheets Nos. 23 N. W., 23 S. W., (4th edition)	1	4	Additions to date.
UPPER BURMA (SOUTH-EAST FRONTIER SERIES)—			
Sheets Nos. 1 S. W., 1 N. W. .	2	4	Completed.
Sheet No. 2	1	8	Additions to July 1891.
Sheets Nos. 2, 4, and 6 . .	3	8	In progress.

DRAWING OFFICE, CALCUTTA.

SECTION I—*continued.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
Administration Report Maps, Bengal.		Miles per inch.	
Champarun	1	8	In outline for engraving.
NORTH-WESTERN PROVINCES AND OUDH—			
Azamgarh, Bahraich, Basti, Barabanki, Bijnaur, Fyzabad, Gorakhpur, Hamirpur, Hardoi, Kheri, Lucknow, Muzaffarnagar, Partabgarh, Pilibhit, Shahjahanpur, Sultanpur, and Unao	17	8	Redrawn in outline for engraving.
Kumaun	1	10	Hill shading in brush for engraving.
Index Maps.			
Various descriptions	9	Various.	Corrected to 30th September 1891.
Miscellaneous Maps.			
Soonderbuns	1	4	Corrected with additions.
Kubo Valley and Lekayam	1	4	A tracing for Quarter Master General.
Western and Eastern Bengal	20	8	Additions and corrections.
A plate showing symbols used in Topographical drawing	1	...	In progress for departmental use.
Skeleton map of Manipur and Silchar	1	8	Prepared for Quarter Master General.
Town of Rangoon	9	400 ft.	Additions and corrections.
Southern Waziristan	1	2	Additions about Gumal Pass.
Map of Hastadan	1	2	Showing Major-General McLean's final demarcation.
Triangulation Charts.			
Chin-Lushai Expedition	1	4	Completed.
Himalayan Peaks between Long. 84° and 87°	1	8	Projected and drawn.
Work done for other departments.			
BENGAL—			
Income Tax	3	80	Showing (1) distribution, (2) proportion of persons assessed, (3) incidence of taxation in 1890-91.
Emigration	2	80	Showing districts of emigration and registration.
Mortality	2	80	Showing fatal fever and small-pox during 1890.
Revenue	6	80	Different maps showing sources of excise revenue.
Police	4	80	Showing different crimes.
Revenue	1	16	Showing saliferous districts.
ORISSA DIVISION—			
Revenue	1	16	To illustrate Salt Administration Report.
INDIA—			
Emigration	1	96	Showing registration districts.
Emigration	1	96	Showing the native districts of Colonial emigrants.
Statistical	1	64	Additions to date.
Maps of Central India Agency, Kashmir, N.-W. Provinces and Oudh, Nepal, Central Provinces, Sind and Baluchistan, Sistan, Punjab, Bombay, Madras, Rajputana, Arabia, and East Africa, Bengal, Behar, Orissa, and Chota Nagpur	14	32	Preparing for Aitchison's Treaties.

DRAWING OFFICE, CALCUTTA.

SECTION I—*concluded.*

Statement of work.

DESCRIPTION OF WORK.	Number of Sheets.
Maps examined.	
Atlas sheets	74
General maps	21
Provincial maps	22
Divisional maps	5
District maps	14
Standard maps	84
Administration Report maps	22
Index maps	5
Statistical maps	85
Triangulation charts	15
Miscellaneous maps (departmental)	55
Do. (extra-departmental)	27
Engraved proofs of Atlas sheets in various stages	130
Engraved proofs of general and provincial maps, including index charts	62
Engraved proofs of district maps	44
Lithographic proofs of general and provincial maps, including index charts	47
Lithographic proofs of Atlas sheets and district maps transferred from copper-plates	10
Lithographic proofs of extra-departmental and statistical maps	2
Photographic proofs of standard maps, large scale plans, and various other maps	454
Colouring of maps for office use	23
Tracings of maps for various purposes	2
Projection and examination of graticules and plotting of points	47
TOTAL	1250

N.B.—In addition to the above many miscellaneous jobs, such as supply of geographical data to various officials, calculation of areas, computation of graticules for the projection of the sheets of the Indian Atlas, examination of the proof sheets of the Survey of India Notes, as to the correct orthography of names, etc., have been performed by the Examining Section.

SECTION II.—REVENUE.

Statement showing the work performed during the year 1890-91.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
STANDARD MAPS.			
PUNJAB.			
District Hissar.			
Sheet No. 256	1	1/2	Canals and village sites inserted from the Survey of 1889-90 and names retyped.
Sheet No. 241	1	1	Ditto.
Sheet No. 241	1	1/2	Names retyped, reduced to 1/2 scale, and completed to margin for a second edition.
District Jullundur.			
Ludhiana, Hoshiarpur, and Umballa.			
Sheets Nos. 211, 212, 247, and 248	4	1	Originals and proofs examined, corrected, and sent to press.
Sheets Nos. 223, 224, 234, 235, 236, 237, and 238	7	1	Originals and proofs examined.
Sheets Nos. 291 and 292	2	1	Originals examined, and completed to margin for a second edition. Proofs examined and passed with press order.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
STANDARD MAPS—*contd.*			
District Jullundur—continued.			
Sheets Nos. 213, 227, 294, 313, and 316	5	1	Proofs under examination.
Sheets Nos. 239, 240, 254, and 255	4	1	Canals, village sites and names inserted from the Survey of 1889-90; also contours from tracings received from the Irrigation Department. Proofs under examination.
District Hazara.			
Sheets Nos. 1, 2, 5, 10, and 13	5	1	Originals passed with press order.
Districts Jhang and Dera Ismail Khan.			
Sheets Nos. 99, 118, and 143	3	1	Proofs examined. Press order given.
Sheets Nos. 116, 117, 142, 143, 145, 168, and 169	7	1	Examined and proofs under correction.
District Peshawar.			
Sheets Nos. 5 and 9	2	1	Originals passed with press order.
District Gurdaspur and Jummoo Territory.			
(Chak Andhar.)			
Sheets Nos. 231 $\left(\frac{NE}{9}, \frac{SE}{2, 3, 5, 6, 9}\right)$, 232 $\left(\frac{NE}{3}\right)$, 246 $\left(\frac{SW}{2, 4, 7}\right)$, 247 $\left(\frac{NW}{1}\right)$	11	½	Examined, proofs passed, and press order given.
NORTH-WESTERN PROVINCES.			
Districts Gorakhpur and Basti.			
Sheets Nos. 188, 189, 190, 191, 192, 203, 204, 205, 206, 213, 214, and 215	12	1	Proofs passed and press order given.
District Basti.			
Sheets Nos. 163, 173, 174, 175, and 176	5	1	Ditto.
District Mirzapur.			
Sheets Nos. 167, 168, 181, 184, 197, 198, and 199	7	1	Proofs passed and press order given.
OUDH.			
Sheets Nos. 99, 100, 113, 114, 115, 145, 158, 159, 172, and 173	10	1	Ditto.
Sheets Nos. 160 and 161	2	1	Proofs under examination.
BENGAL.			
District Mymensingh.			
Sheets Nos. 343, 361, 363, and 374	4	1	Proofs examined.
Sheets Nos. 344, 345, and 360	3	1	Proofs examined and sent to press.
District Darjeeling.			
Sheets Nos. 269, 270, 271, 292 and 293	5	1	Corrected up to date. Proofs under examination.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
STANDARD MAPS—*concld.*		Miles per inch.	
ASSAM.			
Districts Darrang and Kamrup.			
Sheet No. 138	1	½	Fair maps under examination.
Sheets Nos. 26, 27, 28, 40, 41, 49, 50, and 51	8	½	Names typed. Held in abeyance.
District Lakhimpur.			
Sheets Nos. 1 to 15	15	½	Graticule lines inserted, names inserted and boundaries corrected.
CENTRAL PROVINCES.			
District Sambalpur.			
Sheets Nos. 236, 237, 238, 239, 251, 252, 253, 254, 262, 263, 264, and 265	12	1	Fair maps and proofs examined and press order given.
BOMBAY.			
Sheets Nos. 145, 146, 233, 277, 332, and 333	6	1	Proofs passed with press order.
Sheets Nos. 179, 185, 244, 331, 352, 353, and 353a	7	1	Fair maps examined and press order given.
BURMA (LOWER).			
Sheets Nos. 229, 230, 235, 236, 275, 277, 278, and 322	8	1	Proofs passed with press order.
Sheets Nos. 282, 283, 323, 324, 325, 327, and 328	7	1	Proofs examined and press order given.
Sheet No. 227	1	1	New material added for a second edition. Proof examined and sent to press.
Sheets Nos. 180 and 228	2	1	Corrected to date and proofs passed with press order.
Sheet No. 181	1	1	Corrected to date for a second edition.
District Akyab.			
Sheets Nos. 7, 8, 9, 24, 25, 26, 27, 43, 44, and 46	10	1	Proofs passed.
PARGANA MAPS.			
BENGAL.			
District Balasore.			
Sheets Nos. 1 to 9	9	1	Printed sheets touched up for reproduction by photography, proofs passed, and press order given.
District Backergunge.			
Sheets Nos. 2, 6, and 10	3	1	Ditto ditto.
District Bankoora.			
Main Circuit map No. 1	1	1	Ditto ditto.
District Bogra.			
Main Circuit No. 5	1	1	Ditto ditto.
District Chittagong.			
Sheets Nos. 1 to 5	5	1	Ditto ditto.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
PARGANA MAPS—*contd.*			
District Cuttack.			
Sheets Nos. 1 to 9 . . .	9	1	Printed sheets touched up for reproduction by photography, proofs passed, and press order given.
Irrigation Survey.			
Sheets Nos. 6, 9, 18, 19, 22, and 23	6	½	Ditto ditto.
District Dacca.			
Sheets Nos. 1 to 6 . . .	6	1	Ditto ditto.
District Manbhoom.			
Sheets Nos. 1, 3, 11, 17, and 18	3	1	Ditto ditto.
District Monghyr.			
Sheets Nos. 1 to 13 . . .	13	1	Ditto ditto.
District Nuddea.			
Sheets Nos. 1 to 8 . . .	8	1	Ditto ditto.
District Pubna.			
Sheets Nos. 1, 2, 7, 11, 12, and 13	6	1	Ditto ditto.
District Sarun.			
Sheets Nos. 1, 4, 9, 10, 11, 12, 15, 16, 19, and 23 . . .	10	1	Ditto ditto.
CENTRAL PROVINCES.			
District Jubbulpore.			
Sheets Nos. 3 and 17A. . .	2	1	Ditto ditto.
PLANS OF CITIES AND CANTONMENTS.			
City of Calcutta . . .	2	½	Proofs passed. Press order given.
Ditto	1	¼	Alterations and additions made.
Ditto	1	½	Number and boundaries of wards inserted, proofs examined, and press order given.
City of Lahore and Mean Meer Cantonments . . .	6	½	Fair maps and proofs examined and press order given.
Peshawar Cantonment . .	4	½	Rendered suitable for photography.
Kamptee Ditto . .	4	¼	Drawn on scale 16 inches = 1 mile for reduction to ½ scale.
City and Cantonment of Satara .	1	½	Proofs received for examination.
MISCELLANEOUS.			
District map of Kumaun and Garhwal	3	4	Route with names and heights of stages inserted for His Excellency the Viceroy of India.
Usar map of Oudh . . .	1	8	Proof passed with final press order.
Reh map of Punjab . . .	8	4	Proofs under examination.
INDEX MAPS.			
For Annual Administration Report	7	...	Drawn.
Ditto ditto . . .	14	...	Corrected to date.

DRAWING OFFICE, CALCUTTA.

SECTION II—*concluded.*

Statement of work.

Title.	Number of Sheets.	Scale.	Remarks.
		Miles per inch.	
PROOFS EXAMINED.			
Photozincographed maps	329	...	
Lithographed maps	37	...	
TRACINGS PREPARED.			
Tracings of sheets	45	...	
Ditto village plans	264	...	
MAPS COLOURED.			
Maps on various scales	123	...	For Surveyor General's Office.
Ditto ditto	123	...	For Deputy Surveyor General's Office.
Ditto ditto	580	...	For India Office.

Description of work.	Remarks.
Computations examined.	
District Saugor, seasons 1886-89.	
Traverse Data, etc., supplied.	
Kathjori and Alanka Rivers, district Cuttack	For No. 8 Party.
Main circuits Nos. 3 and 4, ditto	Ditto.
Nimar and Hoshangabad boundary	For No. 9 Party.
Narsinghpur and Hoshangabad boundary	Ditto.
Main-circuit No. 8, district Seoni (portion of)	Ditto.
Moradabad and Rampur boundary	For No. 5 Party.
Detached portions of Moradabad in Rampur State	Ditto.
Exterior portion of main circuit No. 2, Moradabad	Ditto.
Rungpore and Cooch-Behar boundary	
Village traverses supplied, 305 pages	To public officers.
Field area statements of *pargana* Raipur, 241 pages	To settlement officer.
Alphabetical lists of villages of 22 *parganas*, district Cuttack.	Ditto.
Values and description of Level Bench Marks, district Hamirpur (34 pages).	To Executive Engineer, Betwa Canal.
Rectangular co-ordinates of triangulated stations in district Nimar.	For No. 14 Party.
Miscellaneous.	
Calculated spherical co-ordinates of Revenue Survey Stations in districts Lakhimpur, Jubbulpore, and Saugor; also of points on Sylhet and Tipperah boundary; plotted 3 villages on 4-inch and 16-inch scales; prepared a traverse circuit and plotted 10 sheets Nerbudda River in district Narsinghpur on 4-inch scale; also 6 sheets of Bhagirathi River in district Moorshedabad; compiled map of disputed boundary between Rungpore and Cooch-Behar.	
Calculated areas by *parganas* of 10 sheets North-West Provinces, 12 sheets Central Provinces, and also areas of districts Rohtak, Karnal, Hissar, Jullundur, Gujranwala, Shahpur, Hoshiarpur, Gujrat, Montgomery, Ludhiana, Ferozepore, Jhelum, Rawalpindi, Amritsar, Muzaffergarh, Jhang, Simla, Mooltan, Kohat, Lahore, Peshawar, Dera Ghazi Khan, Sialkot, and Gurdaspur. Prepared a Table of distances in chains corresponding to a subtense of 10 feet, and examined another corresponding to a subtense of 20 feet. Calculated offset areas and completed traverses of the *jaghir* villages of district Ajmere-Merwara left incomplete by survey party. Calculated areas of Native States in Central India Agency and also of those in Rajputana Agency.	

DRAWING OFFICE, CALCUTTA.

SECTION III.—CADASTRAL.

State of Publication of Cadastral Maps on the 30th September 1891.

DISTRICTS.	NUMBER OF SHEETS.							REMARKS.
	MAPS PREPARED.			PUBLISHED.				
	Up to 30th September 1890.	Added during past 12 months.	Total up to 30th September 1891.	Up to 30th September 1890.	By Surveyor-General's Office during past 12 months.	Total to 30th September 1891.	Remaining to be published.	
North-West Provinces.								
Agra	2,942	...	2,942	2,942	...	2,942	...	
Azamgarh	930	...	930	930	...	930	...	
Ballia	1,601(*a*)	...	1,601(*b*)	1,001	...	1,601	...	
Banda	3,317	...	3,317	3,317	...	3,317	...	
Basti	5,505	...	5,565(*b*)	4,853	712	5,565	...	(*a*) Figures of previous return have been changed to agree with final results.
Benares	2,052	...	2,052(*b*)	2,052	...	2,052	...	
Bijnour	31	...	31	31	...	31	...	
Dehra Dun	701	...	701	701	...	701	...	
Fyzabad	14	...	14	14	...	14	...	
Ghazipur	4,021(*a*)	...	4,021(*b*)	4,021	...	4,021	...	
Gorakhpur	8,637(*a*)	...	8,637(*b*)	5,166	1,437	6,603	2,034	(*b*) These figures are liable to alteration until publication has been completed.
Hamirpur	2,926	...	2,926	2,926	...	2,926	...	
Jaunpur	3,583(*a*)	...	3,583(*b*)	3,583	...	3,583	...	
Kumaun (Bhabar)	...	332	332	...	...	...	332	
Moradabad and Tarai	4,023	...	4,023	4,023	...	4,023	...	(*c*) These maps have been printed.
Muttra	1,658	...	1,658	1,658	...	1,658	...	
Mirzapur	3,794(*a*)	...	3,794(*b*)	3,710	84(*c*)	3,794	...	
Tarai	409	453	862(*b*)	409	...	409	453	
TOTAL	46,204	785	46,989	41,937	2,233	44,170	2,819	
Burma.								
Akyab	2,785	...	2,785	2,741	44	2,785	...	
Bassein	3,437	...	3,437	3,437	...	3,437	...	
Hanthawaddy and Pegu	4,601	...	4,601	4,601	...	4,601	...	
Henzada	1,391	...	1,391	1,391	...	1,391	...	
Prome	847	...	847	847	...	847	...	
Tharrawaddy	1,363	...	1,363	1,363	...	1,363	...	
Thongwa	2,304	460	2,764	1,081	939	2,020	744	
TOTAL	16,728	460	17,188	15,461	983	16,444	744	
Bengal.								
Patna and Gya	3,054	...	3,054	3,054	...	3,054	...	
Pooree (Khorda Estate)	4,565	...	4,565	4,565	...	4,565	...	
Shahabad	4,924	...	4,924	4,924	...	4,924	...	
Mozufferpur	1	...	1	1	...	1	...	
TOTAL	12,544	...	12,544	12,544	...	12,544	...	
Assam.								
Darrang	718(*a*)	...	718	704	...	704	...	
Kamrup	1,675	...	1,675	1,675	...	1,675	...	
Nowgong	753	...	753	534	196	730	23	
Sibsagar	...	1,877	1,877	...	1,037	1,037	840	
Sylhet	61	...	61	16	...	16	45	
TOTAL	3,207	1,877	5,084	2,929	1,233	4,162	908	
Central Provinces.								
Raipur	43	...	43	43	...	43	...	
TOTAL	43	...	43	43	...	43	...	
GRAND TOTAL	78,726	3,122	81,848	72,914	4,449	77,363	4,471.	

Abstract of work performed during 1890-91.

PROVINCES.	NUMBER OF SHEETS.				REMARKS.
	Examined and rendered suitable for photo-zincography.	Traced and examined for zincography.	Proofs examined previous to press order.	Prints coloured and subsequently examined.	
North-West Provinces	2,243	172	2,282	2,233	Scale 16 inches = 1 mile.
Burma	410	610	966	983	Ditto.
Bengal	...	...	...	...	...
Assam	842	433	1,254	...	Ditto.
TOTAL	3,495	1,215	4,502	3,216	

ENGRAVING OFFICE, CALCUTTA.

Statement showing the work performed during the year 1890-91.

Title of Map.	Number of plates.	Outline, square inches.	Number of letters cut.	Hills, square inches.	Remarks.
Engraving.					
Atlas of India.					
Scale 1 inch = 4 miles.					
Quarter sheets (new) completed	2	10	3,980	9	
Ditto in progress	53	783	120,096	618	
Additions and corrections to published quarter sheets	37	254	11,574	88	
Additions and corrections to published full sheets	19	389	4,810	323	
New plates projected, etc.	2	...	...	...	
General Maps	26	403	57,421	56	
Provincial Maps.					
On scale 1 inch=16 miles	13	318	41,062	32	
On various scales for Administration Reports	9	33	4,461	32	
District Maps.					
On scale 1 inch=4 miles	1	94	...	...	
On various scales for Administration Reports	44	1,139	38,082	134	
Index Maps	5	77	12,952	...	
Charts	2	...	260	...	
Miscellaneous subjects	20	...	5,748	...	
Totals	233	3,500	300,455	1,292	

Copper-plate Printing.

Impressions taken	20,129
Proofs pulled	537
Transfers pulled	434
Total	21,100

Steel-Facing.

Double elephant plates steel-faced	17
Do. do. steel removed	12
Quarter sheets steel-faced	45
Do. steel removed	28
Miscellaneous plates steel-faced	14
Do. do. steel removed	6
Total	122

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE, CALCUTTA.

Extract from the Narrative Report of COLONEL J. WATERHOUSE, S.C., *Assistant Surveyor-General, Season 1890-91.*

OUT-TURN.—The out-turn again shows a very large increase in almost all items, and the office has been worked at full pressure throughout the year.

ORIGINAL SUBJECTS.—The total number of original subjects received for reproduction during the year has been 7,067 (inclusive of 4,376 cadastral maps), of which 662 have been lithographed, and the remaining 6,405 reproduced by various photographic processes and by zincography. The increase over last year on the whole is about 46. The number of departmental maps, plans, and forms lithographed was 62, or 81 less than last year: 600 original subjects were lithographed for other departments, or 12 more than last year.

The total number of subjects received for photographic reproduction was 6,405, of which 1,083 were departmental, 4,376 cadastral, and 946 extra-departmental. Last year the numbers were 1,068 departmental, 4,548 cadastral, and 674 extra-departmental, showing differences of +15, —172, and +272 respectively.

LITHOGRAPHIC DRAWING SECTION.—The total number of new drawings or additions made to maps, etc., on stone, taken up and completed during the year, was 744; of these 101 were departmental, the remaining 643 being for other departments. Last year 645 subjects were received, of which 57 were departmental and 593 extra-departmental. The section has remained under charge of Mr. H. L. Lepage, Head Assistant; beyond the heavy pressure of work throughout the year there is nothing to record.

PHOTOGRAPHIC NEGATIVE SECTION.—The total number of negatives taken during the year was 5,694, including 69 reversed negatives and transparencies for use in the helio-gravure process: of these 1,320 were of departmental, 3,211 of cadastral, and 1,163 of extra-departmental maps, plans, and drawings, as against 1,308 departmental, 3,241 cadastral, and 1,051 extra-departmental last year. The section has been under charge of Mr. H. Haward, except for three months, when he was on privilege leave, and Mr. Harrold took over the charge of it. There have been no changes in the processes.

PHOTO-TRANSFER PRINTING SECTION.—The number of photo-transfer prints prepared was 5,579, of which 1,276 were departmental, 3,257 cadastral, and 1,046 extra-departmental, and there is an increase of 431 over last year. Mr. J. Harrold remained in charge of the section, except for three months as above reported, when he was in charge of the Negative Section. There have been no changes in the processes. Some fairly successful trials were made with Husband's process for half-tone work, and it was found a very great advantage to harden the glue rollers, used for inking up the transfers, by sponging them with spirit of wine and then with a saturated solution of chrome-alum. Rollers so prepared showed no tendency to mould or decompose during the rains. The following formula for preparing grained half-tone transfers was found to work well in the wet season and hot weather:—

Gelatine	135 parts.
Water	1,080 „
Chrome-alum	1 „
Salt	45 „

LITHOGRAPHIC AND ZINCOGRAPHIC PRINTING SECTIONS.—As explained last year, the work of these two sections has again been more or less combined, though the two establishments have not been formally amalgamated. In the Lithographic Printing Section the number of subjects printed from stone was 681, of which only 74 were departmental, the number of extra-departmental subjects being 96 more than last year; the number of pulls was 283,819, or about 3,255 more than last year, and of copies 329,027, as compared with 256,909 of last year. In the Zinc-Printing Section (normal) the number of plates printed was 1,127, of which 667 were departmental and 460 extra-departmental; the number of pulls was 276,602 (111,485 departmental and 165,117 extra-departmental), and of complete copies 288,822, of which 108,724 were departmental and 180,098 extra-departmental. As compared with last year this shows an increase of 86 in the number of plates printed and of 66,968 in the number of pulls, though the number of copies is 17,658 less. The work has again largely increased in this section. In the Zinc-Printing Section (cadastral) 4,484 plates of cadastral maps of the North-West Provinces, Burma, and Assam were printed off, the number of pulls being 151,557, and of copies of complete villages 142,519, as against 4,499 plates, 108,799 pulls, and 99,354 complete copies printed off last year.

The two litho-printing machines have been constantly at work during the year, and have turned out a large amount of work which could not otherwise have been done. The large machine has so far not been used very much for printing from stone, as most of the current work is done on zinc for convenience, though some of the finer class of maps might well be done on stone. It was hoped that the sheets of 1-inch squares for the use of the cadastral surveys might have been printed in the large machine, but it was found impossible to print the hard, dry, hand-made paper in the machine, and they have consequently to be printed by hand. The machine-work has so largely increased that it was found desirable to provide a second machine to meet increased demands, and also to provide a reserve in case of the present machine being disabled. We have now become so dependent on the machine for getting through the work that a break-down would bring us to a standstill.

A second quad-crown machine of a rather lighter make than the present one has been indented for from England.

TYPE-PRINTING SECTION.—The work in this section is slightly in excess of last year. The number of items set up was 9,098, and the number of impressions or pulls 1,074,280, and of copies 581,690. Last year the number of items was 9,918, of pulls 1,061,577, and of copies 573,885. The section has continued under Mr. DePyvah, and the machinery attached to it has all worked well.

SILVER-PRINTING SECTION.—As was the case last year this section has been principally engaged in producing blue-prints for proofs and other purposes. The total number of these prints made during the year was 2,691 against 2,823 of last year, showing a decrease of 132. On the other hand, the number of silver prints shows a large increase of 926, the number of prints being 1,105 against 179 of last year.

HELIOGRAVURE SECTION.—This section has been under charge of Mr. Turner during the year, and has made very good progress; 70 plates have been prepared by the photo-etching process, and 34,015 copies printed from them, showing an increase of 14 in the number of plates and of 3,426 in the number of copies over last year. The process of half-tone block printing, alluded to in last year's report as under trial, has been brought into practical use for preparing the illustrations of Mr. Cotes' reports on Economic Entomology to be printed with type, and 34 blocks were thus prepared.

PHOTO-ETCHING PROCESS.—No change has been made during the year in the original method of working this process. The principal part of the work done during the year has been the reproduction of the exceedingly delicate Indian ink and pencil drawings of insects prepared in the Indian Museum to illustrate Mr. Cotes' reports on Economic Entomology; and as very large numbers of prints have been required of them, it was necessary to find some way of etching the plates sufficiently deeply to stand the printing, and at the same time to print them in such a way as to preserve the delicacy of the originals. Mr. Turner successfully accomplished this by biting the plate much deeper than usual, and printing with a light grey ink containing a large quantity of zinc-white in it. In order to overcome the general greyness given to the print, a few of the very deepest shadows were deeply cut with the graver. Some very good sparkling effects were produced by this means, and large numbers of prints could be made without the plates wearing. Seventeen of these plates were prepared; the printing, amounting to 31,000 impressions, is still in hand. A very successful reproduction of a colored plate was prepared for the "*Scientific Memoirs by Medical Officers of the Army in India*." It consisted of several microscopic drawings illustrating the condition of the vessels in the initial stage of *mycetoma*: these drawings were in different shades of blue, violet, and strong reddish orange. The negative was made on an orthochromatic plate which brought out all the detail fairly well, though the transparency required a good deal of touching up. The printing of the etched copper plate was done as nearly as possible in the original colours, the different coloured inks being applied with dabbers on the several diagrams, and wiped off in the usual way, but in such a direction that they did not blend. The printing was necessarily slow, but took less time than it would have done to have printed the copies in the ordinary way and to have coloured them by hand, while the effect was really much better and a truer copy of the original. A copy of this plate is appended to this report. Twenty-one plates were done for the "*Technical Art Series*," of which 14,700 copies were printed. Trials were made with the object of bringing out an edition of the new survey of the city of Calcutta on one-fourth the original scale by joining nine reduced sheets so as to form a single sheet. The result showed that the work might be done with good effect, but as the drawings were too full of detail and had not been drawn with the object of reduction, a great deal of stopping out had to be done, and it was finally decided to prepare the reductions from fresh drawings. The plate attached to the report of this survey at page 92 shows with what delicacy such reductions can be produced, and the good effect with which shaded tints can be introduced on the copper plates by an after process of etching.

Two sections of the 24-mile map of Afghanistan were etched during the year, and it is to be regretted that this beautiful process cannot be more largely utilised for map work.

PHOTO-BLOCK PROCESS.—During the year Mr. Turner has devoted a good deal of attention to working out a method of producing good photographic half-tone blocks. The following method was found successful, and was used for preparing a large number of blocks of shaded drawings to illustrate the reports on Economic Entomology prepared by Mr. Cotes of the Indian Museum.

A grained negative has first to be obtained by placing a transparent screen of crossed and closely ruled lines (about 150 to the inch) in contact with a transparent positive cliché of the subject to be reproduced, and then taking a negative in a copying camera. The result is a negative in which the gradations of shade are broken up into a network, enclosing small points varying in size and character according to the amount of exposure received in different parts of the film. In the darkest parts of the negative, which represent the lights or white spaces of the finished print, these points have the appearance of small transparent dots joined by opaque spaces, and as the negative increases in transparency, corresponding to the increasing depth of shade on the print, the transparent dots increase and the opaque spaces lessen till in the deepest shadows the distribution of light and shade is quite reversed and the negative image is formed by very small opaque dots joined by transparent spaces and finally by absolute transparency. The screens used were photographic reproductions of some ruled prints I obtained from Herr Türcke, formerly of

Donauwirth and now of Munich, but it is difficult to photograph such fine lines sufficiently clearly and sharply to give the best results. Experiments were tried in ruling plates direct on the glass by the ruling machine in the Engraving Office. A sheet of plate glass carefully cleaned was coated evenly with a thin film of India-rubber solution, which, when set, was dusted over with fine plumbago; this gave a perfectly opaque film which cut well in the ruling machine. The difficulty is to rule the lines over a large surface with absolute regularity.

While on furlough I obtained some specimens of ruled screens from Mr. Max Levy of Philadelphia, United States of America, and trials made with them after my return have shown their great superiority over anything we could make here. I had already ordered a screen from Mr. Wolfe, another American manufacturer, before I had seen Mr. Levy's, but as soon as the requirements of the process are better known, it is probable that it will be necessary to provide ourselves with various sized screens of different rulings.

Having obtained a good grained negative the rest of the process is very simple and reliable in its working. A thin and highly polished copper-plate is coated with a very fine grain of asphalt in the dusting box, in the same way as for the photo-etching process. The grain should be very fine, so as to be eaten away during the etching of the image. The thin copper plates used are best produced by electro-typing, and are not much thicker than a sheet of stout paper. The metal is thus of good quality and surface, and can be easily cut and handled. Copper is less liable than zinc to be corroded. The further steps of the process are described by Mr Turner as follows:—

"A print in standard brown autotype tissue is now taken from the grained negative and developed in the ordinary manner on the thin copper-plate; a quantity of prints may be developed on the same plate and etched together or separately. They should be printed in the direct sun-light and take an exposure of one to two minutes. They are dried off in the usual way with spirits of wine, and the parts not requiring etching are masked out with asphalt varnish: before etching the prints should be carefully examined to see that there are no defective parts, and especially that the grain is crisp and sharp; the slightest want of contact in the printing will spoil the result.

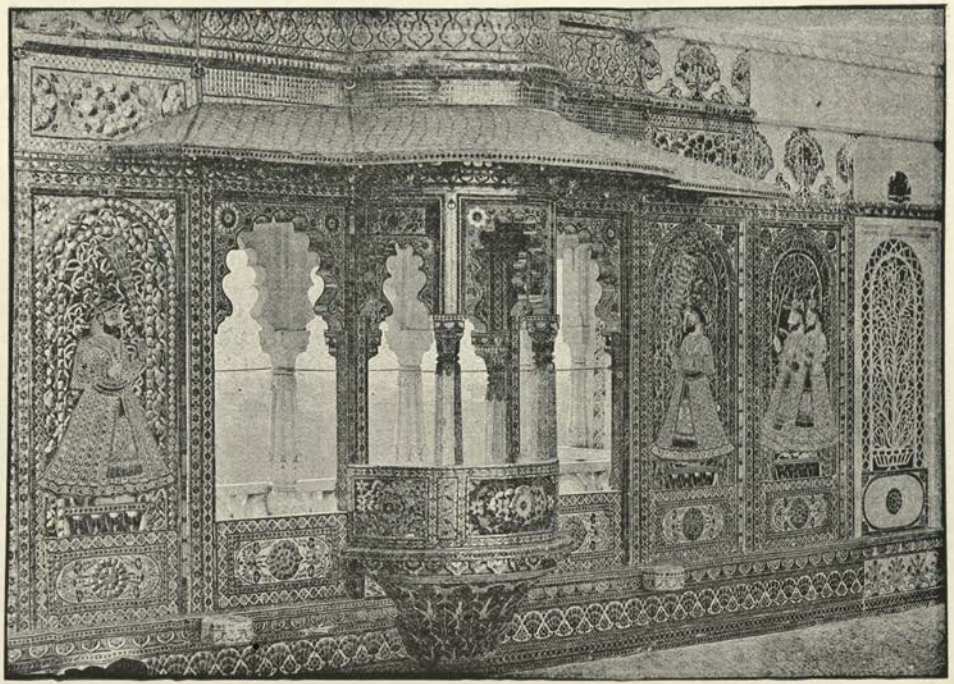
"The image on the copper-plate is now placed in a solution of perchloride of iron of 44° Baumé and the process of etching carefully watched; from the time that the perchloride first begins to attack the copper, which is easily seen, the plate should be in the solution about 10 to 12 minutes, or until the greater part of the image is etched; it is now removed to another dish containing a 40° Baumé solution of perchloride of iron, and left in this until every part of the image has been eaten into the copper, except the very deepest shadows. This generally takes about 6 to 8 minutes; the gelatine image is then washed off in a strong current of water, and the plate cleaned with ammonia and chalk. If the etching has been satisfactory, a perfect image in relief will now be obtained with every line of the grained negative reproduced clear and sharp. An advantage of this method of etching is that the grain is never underbitten; the finest lines and dots are always perfect, because if the contrast in the work makes it necessary to over-etch the fine parts, the image is attacked by the perchloride on the surface without removing the original gelatine film, as would be the case in etching an asphalt or fatty-ink image under similar circumstances. The result is that the lights of the picture are slightly below the level of the deep shadows, but not sufficiently so to interfere with the printing; in fact it should assist it considerably by causing the deep shadow to take up more ink than the lights, and so form a natural graduated method of overlaying, so important in typographic printing. The plate now obtained, though fairly deep, is not sufficiently so for printing purposes and recourse must be had to re-biting, which is about the most important part of the process. For this purpose a hard gelatine or smooth rubber roller is required, and the image is carefully rolled up with an ink composed of equal parts of good lithographic ink and black wax thinned down with sufficient lithographic varnish to just make it workable on the slab; the ink should be as hard as possible. The black wax mentioned is composed of—

Spermaceti	56 parts.
Stearic acid	26 „
White wax	24 „
Asphalt	9 „

"With proper care the image is very easily rolled up with this composition, and it forms such a powerful resist to the etching solution that a very thin film will be found sufficient to protect the image. The plate is slightly warmed over a gas stove, and the back and sides of it again covered with asphalt varnish. It is then put into a 38° solution of perchloride of iron, and should stand about 2 minutes etching; this will deepen the image considerably, but will have to be repeated a second and very often a third time before sufficient depth is obtained, care being taken that between each rebiting the plate is thoroughly cleaned with benzole and turpentine. A great deal can be done with the plate to improve it during the progress of the rebiting by painting out and biting only such parts of the plate as may require it, but this of course depends entirely upon the subject and the skill of the operator.

"The plate is now cut to the exact size required and is ready for mounting. The plates being very thin, this is easily effected by fastening them to blocks of wood, type-high, with strong bichromated gelatine. The back of the plate must be first carefully

PHOTO. BLOCK. BITUMEN-GRAIN PROCESS.

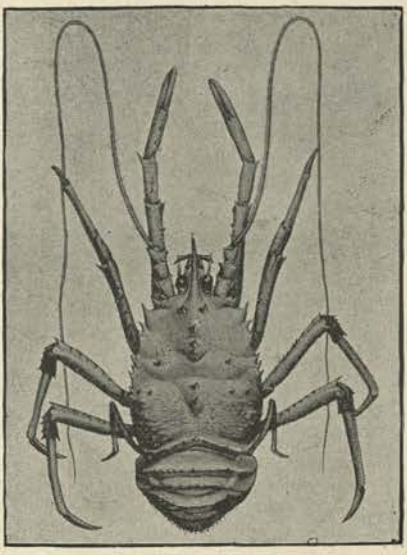


Survey of India Offices, Calcutta, January 1892.

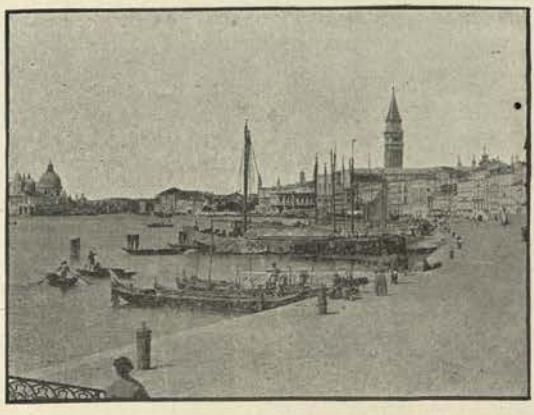
COLOURED GLASS MOSAIC IN THE PALACE AT OODEYPORE, RAJPUTANA.

From a Negative by O. S. Baudesson, Ajmir.

SPECIMEN OF PHOTO. BLOCK PRINTING.



Reduction from an Indian ink drawing.



VIEW IN VENICE.

From a Negative by Colonel J. Waterhouse.

ETCHED ON THIN ZINC BY THE ASPHALT PROCESS FROM NEGATIVES TAKEN WITH MAX LEVY'S ENGRAVED RULED SCREEN, 150 LINES TO THE INCH.

Survey of India Offices, Calcutta, March 1892.

cleaned with turpentine and afterwards with a strong solution of caustic potash; it is then dried, and a sheet of white tissue paper is attached to it, with a solution of—

Gelatine	8 parts.
Water	32 ,,
Bichromate of potash	1 part.

"Upon the wooden block a sheet of thin drawing paper is attached with the same solution. The plate with the tissue paper on its back is now thickly coated with the bichromated gelatine, as also the wooden block, and the two brought into close contact with each other and placed under pressure. The method adopted for this purpose is to place a sheet of oiled paper on a plate of glass, and placing the mounted blocks upon this, face downwards, to put a quantity of sheets of plate glass on top of them, these are left till the next day, when it will be found that they are firmly attached to the wooden blocks and very level. The typographic images can be easily touched up with a roulette or burnisher for the purpose of bringing out lights or deepening shadows. Thirty-four blocks were done by this method for Vol. II, Part I, of the Indian Museum Notes, and sent to the Government Printing Office to be printed with the text.

"Some further experiments were also tried with the "bitumen-grain" process described in the Annual Report for 1886-87, originally taken from the *Jahrbuch für Photographie and Reproductions Technik* for 1887, as practised at the State Printing Office at Berlin. Very promising results were obtained, as will be seen from the accompanying plate, and with further practice the process may probably be found one of great utility producing more artistic effects than a mechanically ruled plate."

Since my return from furlough, further experiments have been made with good results, using the new ruled screens and thin zinc plates and asphaltum instead of copper and gelatine. Specimens of the results obtained are annexed.

Electrotyping hand-engraved plates has been carried on steadily during the year, the number of plates electrotyped being 26, against 9 of the previous year. The demands for this kind of work have very much increased lately but have been met without difficulty. During the rainy months there has for some years past been a difficulty in avoiding a spongy deposit of the copper, and it was the same last year. This defect appears to be due to the weather, as it re-appears yearly about the same time. The leather diaphragms lose their porous nature to a great extent during the hot and moist part of the year, and seem to become soft and gelatinous.

EXPERIMENTAL AND PERSONAL WORK.—In the early part of the year under review I was fully occupied in working out the process of taking reversed positives direct in the camera, which was brought to notice in my last report. My absence on furlough to Europe for six months has prevented me from going much further into the practical working of the process than was described in last year's report. Professor Reynolds' compound salt of thio-carbamide and ammonium bromide still gives the best results. Some of this salt was prepared for me by Messrs. Hopkin and Williams. It is conveniently soluble in about 100 parts of alcohol, and of this solution about 1·5 to 2 parts may be added to the following developer:—

Eiko nogen	1
Lithia carbonate	1
Soda sulphite	1
Water	100

Very good reversals have also been obtained with a compound of thio-sinamine and ammonium bromide added in small quantity to the above developer.

I obtained some other thio-carbamides from Europe for trial, but owing to delays they did not arrive till just before my departure on leave, and I was unable to try them properly then, nor have I had the opportunity since. Some rough trials that were made showed that ethyl-thio-carbamide might be useful with a very weak eikonogen-lithia developer restrained with bromide, but it produces images of a strong yellow colour. Methyl-thio-carbamide also seemed likely to be useful. Amyl-thio-carbamide seemed to have a very powerful reversing effect, and also to exert a strongly solvent action on silver bromide. Ditolyl-thio-carbamide, though almost insoluble in water, seemed to exercise a very powerful effect on the developer. Although it showed no sign of reversal, the image on an ordinary slow plate with a very short exposure was full of detail and very dense. Some selenium-urea was kindly made up for me by Dr. Schuchardt of Görlitz, and trials made of it in Europe failed to show any reversal. It is possible, however, that the compound had become decomposed by contact with the air.

I have been able to confirm the indications of reversed electro-chemical action during the development of bromide of silver films with eikonogen developers containing thio-carbamides, and with the aid of a more delicate galvanometer obtained from Dr. Edelmann in Munich, I was also able to obtain evidence of electrical currents, in some cases amounting to nearly ·1 volt, generated during the development of ordinary dry plates with various developers. The results actually obtained are somewhat conflicting, because the currents were found to flow in different directions without apparent cause, and further investigation is required to ascertain clearly to what cause the electrical action observed is due, and what connection it has, if any, with the influence of light on the sensitive film.

Some trials were made privately of the new primuline printing process which was brought out in England during the year, but it was found quite unsuitable in its present form for ordinary photographic printing, owing to the strong yellow colour of the ground of the pictures produced by it.

While on furlough in Europe I took the opportunity of obtaining what information I could about various points connected with the office work, chiefly in the direction of copper-plate printing by machinery and the preparation of photo-blocks in half-tones. I visited the Ordnance Survey Office at Southampton, the Military Cartographic Institute at Brussels, the State Printing Office at Berlin, the National Printing Office and the Photographic Section of the Geographical Department of the Ministry of War at Paris, as well as some private firms in London, Berlin, Munich, and Paris. The result of my enquiries as to copper-plate printing machines, made from the best sources of information in London and the Continent, both official and private, was that at present there is no really satisfactory machine of the kind; the one I saw working in the Paris Exhibition of 1889 has not been a success. I was finally recommended to try what is known as a 'D' copper-plate press to be worked by steam. These presses are largely used for bank-note printing, and save a great deal of time and labour in passing the plate through the press, the yield being about one-third more, though the operations of inking and wiping the plates have still to be done by hand. On my recommendation the Secretary of State has ordered one of these presses to be sent out to the Office.

At Southampton I saw a process of cold copper-plate printing on dry paper in use, with the object of ensuring freedom from distortion, and also to permit of colour printing; the hills being engraved on a separate plate and printed in pencil-grey or some lighter tone than the black. A very heavy pressure is, however, required in printing, and a powerful press has been constructed to be worked by a small Willan's steam engine coupled on to it. The paper being printed almost dry, the blankets do not require to be constantly changed and dried, as is the case with wet paper printing. Some samples of fluid copper plate inks, to be used cold, were obtained from Messrs. Shackell and Edwards, and from B. Winstone & Co., and have been found to give very perfect heliogravure prints and to effect a large saving in gas. The heliogravure plate which serves as frontispiece to this report has been printed with cold ink.

At the Military Cartographic Institute in Brussels, I found that the old method of photo-chromo-lithography in vogue at the time of my former visits had been replaced by a process of photozincography known as *topogravure* which has been in use in the Photographic Section of the Ministry of War, Paris, for some years past. The new process is an immense improvement over the old, as is proved by comparing the old editions of sheets of the map of Belgium on the scale of 1 : 40,000 with the new maps reproduced from the same original drawings. The whole of the printing work is now done on thin zinc plates instead of on stones. Colonel Hennequin, the Director of the Institute, brought to my notice the advantages of using Japanese paper for printing maps that have to be constantly folded. I ascertained that the paper is imported into England by Messrs. Mitsui and Co. of 1, Crosby Square, E. C., and obtained some samples from them. Though excellent for printing work, the paper has proved quite unsuitable for map drawing with corrections, or for hand colouring, being too soft and absorbent.

Unfortunately, at the time of my visit to Berlin, Professor Roese, the head of the Photo-engraving Department of the State Printing Office, was absent, and so I was not able to see much of the photo-engraving or block processes in use. I saw the method of biting the copper-plates for the photo-etching process, which differs from that I learnt in Vienna; in that, instead of a series of baths of perchloride of iron of gradually decreasing strength, a single strong solution is used, and it is diluted with water as required during the progress of the biting in.

The collotype process in use is peculiar, the negative itself being used as the printing plate. The negatives are taken by the ordinary collodion process on plate glass about $\frac{1}{4}$th an inch thick. They are then coated with a solution of—

Gelatine	66 grammes,
Bichromate of ammonia	20 „
Liquid ammonia	20 c. c.
Water	1,400 c. c.

and dried in a box after setting. No heat is used for drying, but the drying box is constructed with a ventilating shaft heated by a gas jet. The printing is done with a machine constructed by Koch, of Leipsic which gives about 300 to 400 impressions an hour. A similar process was tried in this office many years ago, but it was difficult to see the subject on the dark surface of the negative, and the process had the usual defects of collotype printing in this country. I did not see any photo-block printing in progress, nor could I obtain any definite information regarding it.

At Munich I visited Dr. Albert, who has a large establishment for heliogravure and collotype. His negatives are all made with his orthochromatic collodio-bromide emulsion process, and were particularly fine. Since my return I have prepared some similar emulsion, after formulæ given by Dr. Jonas of Vienna and it seems likely to be exceedingly useful, if it may not eventually supersede the wet collodion process for all our copying work. Herr Obernetter showed me some very good specimens of his process of photo-engraving which differs from most similar processes, in that the engraved image is obtained

on the copper by electricity. A specially prepared transparency, containing chloride of silver in gelatine, is placed in close contact with the copper-plate, and, under the influence of the electric current, the choride is decomposed and etches the copper in proportion to the quantity in which it is present in different parts of the image.

At the Photographic Section of the Geographical Department of the Ministry of War at Paris I found the processes much the same as on former visits, but great improvements had been made in the topogravure process, and it was largely worked in a practical way. The principal improvement is the preparation of the plates with a solution of gallic acid, composed of—

Gum arabic	250 grammes,
Gallic acid	15 „
Water	1,000 c. c.

When these have been dissolved with heat add—

Phosphoric acid	25 c. c.

This solution is washed off carefully, and the plates are then coated with bitumen by means of a large turn-table. The plate is exposed under a glass positive produced by contact-printing from the negative upon a dry collodion plate. For colour work as many positives are produced as there are colours, and the superfluous details in each are scraped away—a much more satisfactory method than stopping out a negative. After exposure the bitumen image is developed in turpentine and the lines show clear on a brown ground. After being touched up with varnish to cover holes, etc., the plate is etched with weak nitric acid to destroy the gallic acid and gum preparation, which is protected by the bitumen in the exposed parts forming the ultimate whites of the picture. The plate is then rubbed with oil which renders the etched parts of the plate susceptible of taking up ink, while the gummed parts reject it. The bitumen is then removed and the plate is ready to print. A great deal of colour work is done by this process in connection with the new maps of Tunis and Algeria on the scale of 1 : 50,000.

At the National Printing Office there was nothing much doing in the Photographic Section at the time of my visit, and beyond seeing the establishment I gained no information about new processes.

Specification of Plate or Print.	Sheets or Subjects.	Negatives and transparencies.	Photo-transfer Prints.	Photo-zincographic and Lithographic Printing.						
				Zinc Plates transferred.	Zinc Plates printed.	Stones.	Pulls.	Number of Copies.		
								Coloured.	Uncoloured.	Total.
Departmental Maps and Plans.										
Atlas Sheets	1	...	...	...	...	1	78	...	75	75
General Maps	13	3	3	2	52	14	10,628	500	4,878	5,378
Provincial Maps	43	77	73	27	25	6	2,836	...	2,928	2,928
Divisional Maps	23	26	22	6	2	...	250	...	250	250
District Maps	8	6	6	6	19	11	3,250	...	3,250	3,250
Plans of Cities and Cantonments	49	87	76	19	39	9	3,344	...	2,944	2,944
Standard Maps	481	752	842	290	374	13	58,713	...	53,863	53,863
Index Maps	41	27	38	42	46	40	22,450	15,550	5,650	21,200
Technical Charts	29	34	34	16	24	...	560	...	560	560
Miscellaneous Maps and Plans	450	308	282	23	95	32	33,422	270	41,329	41,599
Transfers and Proofs	...	...	...	...	...	...	2,735	...	...	...
Departmental Forms	7	...	4	...	1	22	40,635	...	40,885	40,885
Type Printings	...	...	...	...	...	...	...	...	...	...
Total	4,145	1,320	1,376	481	667	108	173,878	16,320	156,612	172,932
Cadastral Maps.										
North-Western Provinces—										
Photozincographs	2,140	2,140	2,120	2,110	2,110	...	40,400	...	40,400	40,400
Zincographs	168	...	...	168	168	...	3,066	...	3,066	3,066
Total	2,308	2,140	2,120	2,278	2,278	...	43,466	...	43,466	43,466
Burma—										
Photozincographs	315	315	318	384	384	...	13,065	...	13,065	13,065
Zincographs	580	...	...	580	580	...	20,162	...	20,162	20,162
Total	895	315	318	964	964	...	33,227	...	33,227	33,227
Assam—										
Photozincographs	756	756	819	825	825	...	43,725	...	43,725	43,725
Zincographs	417	...	...	417	417	...	22,101	...	22,101	22,101
Total	1,173	756	819	1,242	1,242	...	65,826	...	65,826	65,826
Transfers and Proofs	...	...	...	...	...	...	9,038	...	...	...
Grand Total	4,376	3,211	3,257	4,484	4,484	...	151,557	...	142,519	142,519

LITHOGRAPHIC OFFICE.

done during the year 1890-91.

Type Printing.			Silver and other Printing.			Heliogravure and Electrotyping.				Value.	Remarks.
Pages or Items.	Folds.	Copies.	Silver Prints.	Blue Prints.	Miscellaneous Prints.	Heliogravure Plates.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.	R a. p.	
...	...	...	...	...	...	...	...	...	...	25 12 0	Six subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	2,664 1 3	Two ditto ditto.
...	...	...	...	...	...	...	...	...	...	2,202 7 9	
...	...	...	...	26	...	...	...	...	...	426 6 0	Seven ditto ditto.
...	...	...	...	...	...	...	...	...	...	2,327 11 0	
...	...	...	...	280	...	...	...	...	...	2,605 6 6	Twenty-four ditto ditto.
...	...	...	...	1,479	...	...	...	...	...	35,063 1 9	
...	...	...	...	155	...	...	...	...	...	2,521 3 3	
...	...	...	...	16	...	...	...	...	...	639 13 9	
...	...	...	9	547	...	12	2,134	...	26	20,665 6 0	
...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	6,284 10 0	
9,098	1,074,280	583,690	...	...	...	...	...	...	...	16,572 5 6	
9,098	1,074,280	583,690	9	2,403	...	12	2,134	...	26	80,987 4 9	
...	...	...	...	...	...	...	...	...	...	132,127 14 6	
...	...	...	...	...	...	...	...	...	...	1,278 14 3	
...	...	...	...	...	...	...	...	...	...	33,806 12 9	
...	...	...	...	...	...	...	...	...	...	5,729 6 6	
...	...	...	...	...	...	...	...	...	...	5,256 0 0	
...	...	...	...	...	...	...	...	...	...	10,985 6 6	
...	...	...	...	...	...	...	...	...	...	26,015 5 9	
...	...	...	...	...	...	...	...	...	...	5,314 12 0	
...	...	...	...	...	...	...	...	...	...	21,330 1 9	
...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	65,722 5 0	

Statement of work done for other

Departments, etc.	Sheets or subjects.	Negatives and transparencies.	Photo-transfer Prints.	Photo-zincographic and Lithographic Printing.					
				Zinc Plates transferred.	Zinc Plates printed.	Stones.	Pulls.	Number of Copies.	
								Colored.	Uncolored.	Total.
Adjutant General in India	27	13	11	3	5	15	2,540	8,320	1,050	9,370
Agent and Chief Engineer, Bengal and N.-W. Railway	8	8		4	4	...	400	...	800	800
Agent and Chief Engr., Rohilkund and Kumaon Railway	7	7	7	4	8	...	800	...	1,400	1,400
Assistant Adjutant General, Bangalore District	2	2	2	1	1	...	200	...	200	200
Asiatic Society, Bengal	19	11	6	3	4	...	2,278	...	4,620	4,620
Board of Revenue, Bengal	9	...	...	32	31	14	13,449	9,833	...	9,833
,, ,, North-West Provinces	34	10	...	...	...	...	...	...	...	...
Calcutta Municipality	8	10	4	3	2	2	2,000	...	2,000	2,000
Chief Commissioner, Burma	3	3	3	1	3	4	1,631	760	186	946
,, ,, Central Provinces	6	8	15	4	4	2	1,140	...	1,140	1,140
,, Engineer, Bengal, Public Works Department	9	27	33	16	18	1	2,210	...	2,470	2,470
,, ,, Irrigation Works, Punjab	37	55	55	19	14	3	2,780	...	3,780	3,780
,, ,, N.-W. Provinces and Oudh P. W. D.	4	...	...	...	...	4	250	...	250	250
,, ,, Zhob Valley Railway	1	...	...	2	2	2	1,000	500	...	500
Commissioner of Chittagong Division	...	...	...	...	1	...	752	...	752	752
,, of Chota Nagpore	...	...	...	3	...	...	...	...	...	...
,, of Excise, Bengal	6	...	...	...	...	8	3,072	2,304	...	2,304
,, of Excise, Punjab	9	...	...	...	3	9	2,580	1,935	...	1,935
,, of Hyderabad Assigned Districts	1	1	1	1	...	...	...	...	...	...
,, of Police, Calcutta	1	...	...	...	...	2	2,084	...	1,042	1,042
,, of Settlement and Agriculture, Centl. Prov.	4	3	...	...	...	2	4,000	...	4,000	4,000
Commissary-General-in-Chief	24	9	2	...	...	7	2,175	...	7,450	7,450
Consulting Engr. to Government of India for Railways	1	...	...	...	...	4	100	...	100	100
Conservator of Forests, Punjab	...	...	...	...	...	...	1,500	300	...	300
Deputy Commissioner, Bilaspur	1	...	...	...	...	1	500	...	500	500
,, ,, Hissar	2	4	4	1	...	...	...	...	...	...
,, ,, Mandalay	93	357	357	77	32	...	1,810	...	2,310	2,310
,, Post Master General, Assam	1	...	...	...	...	1	220	...	220	220
,, Surgeon-General, Central Provinces	...	...	...	...	1	...	275	...	275	275
Director General of Military Works	25	34	34	12	10	3	1,138	6	1,666	1,672
,, ,, of Ordnance, Western Circle	2	1	...	...	...	1	1,190	...	1,190	1,190
,, ,, of Railways	153	124	125	57	63	41	26,340	1,292	41,606	42,898
,, ,, of Telegraphs	136	6	6	5	5	46	23,145	...	54,043	54,043
,, of Agriculture, Assam	...	...	...	...	1	...	390	...	260	260
,, of Land Records and Agriculture, Bengal	30	14	4	2	2	3	3,100	500	2,100	2,600
,, of Land Records and Agriculture, Burma	1	...	...	...	...	6	600	...	600	600
,, of Military Education in India	5	...	...	9	3	7	6,550	900	2,950	3,850
,, of Public Instruction, Bengal	4	...	...	...	...	4	2,340	2,340	...	2,340
,, of Geological Survey of India	7	8	4	1	2	4	2,625	415	2,040	2,455
Engineer-in-Chief, Daltongunge Railway	1	...	...	...	...	3	150	50	...	50
,, ,, East Coast Railway	76	141	157	44	38	...	2,687	...	4,157	4,157
,, ,, Mogul Sarai, Howrah Railway	2	...	...	...	...	2	150	...	150	150
,, ,, Nagpur City	116	60	60	7	...	...	...	...	...	...
,, Port Trust, Kiddepur Docks	5	28	28	10	10	...	1,000	...	1,000	1,000
Executive Engineer, Jhansi Division	1	10	10	6	6	...	150	...	150	150
,, ,, Maywar State	...	...	...	...	3	...	4,270	...	4,770	4,770
Financial Commissioner, Burma	10	11	11	4	4	...	800	...	400	400
,, ,, Punjab	2	8	8	2	1	...	100	...	100	100
General Officer Commanding Manipur Field Force	...	...	...	1	1	...	25	...	25	25
,, ,, Secunderabad District	2	3	3	2	2	...	820	...	820	820
General Supdt., Horse-Breeding Operations in India	...	...	...	...	...	3	495	165	...	165
Government of India, R. and A. Department	166	121	8	1	...	21	17,392	4,270	827	5,097
,, ,, Foreign ,,	29	10	8	2	1	20	584	9	733	742
,, ,, Financial ,,	1	...	...	...	...	1	300	300	...	300
,, ,, Home ,,	1	...	...	...	...	1	23	...	23	23
,, ,, Military ,,	27	6	6	4	4	9	616	...	1,028	1,028
,, ,, Public Works ,,	20	7	7	4	3	13	6,270	850	520	1,370
,, of Bengal, Public Works ,,	1	...	...	...	...	2	52	20	12	32
,, ,, Judicial ,,	3	3	...	...	...	...	...	...	...	...
,, ,, Rev. and Genl. ,,	...	...	...	8	14	...	45,494	33,476	...	33,476
,, ,, Financial ,,	...	...	...	...	...	...	1,212	909	...	909
,, ,, Marine ,,	2	8	8	6	5	2	1,520	...	2,040	2,040
,, N.-W. P. and Oudh, P. W. D.	12	12	22	8	13	...	3,240	...	5,880	5,880
,, Punjab, Public Works Department	86	76	98	28	18	26	9,953	6,400	12,753	19,153
,, ,, Revenue Department	1	...	...	...	...	2	550	...	550	550
,, of Madras	...	...	...	...	...	...	...	...	...	...
,, of Mysore	25	15	...	...	...	...	...	...	...	...
,, Epigraphist, Madras	4	3	4	2	2	...	1,310	...	1,965	1,965
Indian Museum	...	...	...	...	...	...	...	...	...	...
Inspector-General of Artillery	9	...	...	...	...	8	7,000	...	9,000	9,000
,, Ordnance	2	...	...	...	...	3	48	6	6	42
,, Police, Calcutta	4	...	...	...	...	4	1,500	1,500	...	1,500
Leprosy Commissioner	10	2	11	...	...	11	2,539	945	328	1,273
Meteorological Reporter, Government of India	45	...	...	4	8	40	62,715	8,200	58,250	66,550
,, ,, Bengal	4	...	...	1	...	5	18,249	16	18,225	18,241
Municipal Board, Benares	5	20	20	5	5	...	500	...	500	500
Natural History Society, Bombay	...	...	...	...	...	...	...	...	...	...
Officer Commanding Punjab Frontier Force	2	...	...	...	...	2	352	...	152	152
,, ,, Sirhind District	2	2	2	1	1	1	200	...	200	200
,, ,, Nerbudda District	1	5	5	3	3	1	295	...	295	295
Photographic Society of India	5	6	1	3	3	...	2,060	...	2,060	2,060
Port Commissioners, Calcutta	2	2	2	1	2	...	400	...	400	400
Port Officer and Registrar of Wrecks	4	1	1	1	...	4	650	125	275	400
Private Secretary to the Viceroy	...	...	...	...	2	...	85	...	85	85
Carried over	1,332	1,074	960	418	371	360	306,490	86,746	268,279	355,025

LITHOGRAPHIC OFFICE.

Departments, etc., during the year 1890-91.

Type Printing.			Silver and other Printing.			Heliogravure and Electrotyping.				Value.	Remarks.
Pages or items.	Pulls.	Copies.	Silver Prints.	Blue Prints.	Miscellaneous Prints.	Heliogravure Prints.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.	R a. p.	
...	...	...	...	2	...	...	...	...	...	1,428 14 3	
...	...	...	...	...	...	...	...	...	...	214 14 0	
...	...	...	...	...	...	...	...	...	...	298 6 0	
...	...	...	...	...	...	...	...	...	...	66 0 0	
...	...	...	3	4	...	2	1,934	...	...	666 11 3	
...	...	...	...	50	...	...	...	...	...	943 1 9	
...	...	...	...	...	...	...	...	...	...	63 0 0	
...	...	...	3	6	...	3	1,204	...	...	694 10 6	
...	...	...	...	...	...	...	...	...	...	442 5 3	
...	...	...	...	60	...	...	...	...	...	378 12 0	
...	...	...	...	...	...	...	...	...	...	1,101 10 9	
...	...	...	...	...	...	...	...	...	...	1,345 14 6	
...	...	...	...	...	...	...	...	...	...	253 0 0	
...	...	...	...	...	...	...	...	...	...	92 6 0	
...	...	...	...	...	...	...	...	...	...	22 6 3	
...	...	...	...	...	...	...	...	...	...	8 6 6	
...	...	...	...	...	...	...	...	...	...	225 10 0	
...	...	...	...	...	...	...	...	...	...	201 2 0	
...	...	...	...	...	...	...	...	...	...	12 9 6	
...	...	...	...	...	...	...	...	...	...	121 5 0	
...	...	...	...	12	...	...	...	...	...	891 15 3	
...	...	...	...	7	...	...	...	...	...	733 0 0	Six subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	28 13 0	
...	...	...	...	...	...	...	...	...	...	358 2 0	
...	...	...	...	...	...	...	...	...	...	124 7 0	
...	...	...	...	...	...	...	...	...	...	52 12 9	
...	...	...	...	...	...	...	...	...	...	2,711 5 9	
...	...	...	...	...	...	...	...	...	...	250 0 0	
...	...	...	...	...	...	...	...	...	...	42 6 0	
...	...	...	...	...	...	...	...	...	...	612 10 6	
...	...	...	...	3	...	...	...	...	...	47 6 0	Ten subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	4,905 10 0	
...	...	...	...	...	...	...	...	...	...	3,048 10 3	
...	...	...	...	...	...	...	...	...	...	20 0 9	
...	...	...	...	65	...	...	...	...	...	390 3 3	
...	...	...	...	...	...	...	...	...	...	203 13 0	
...	...	...	...	...	...	...	...	...	...	997 15 6	
...	...	...	...	...	...	...	...	...	...	117 6 0	
...	...	...	36	...	...	...	514	...	...	608 6 9	
...	...	...	...	...	...	...	...	...	...	59 0 0	
...	...	...	...	...	...	...	...	...	...	2,792 12 3	
...	...	...	...	...	...	...	...	...	...	38 0 0	
...	...	...	...	...	...	...	...	...	...	579 9 9	
...	...	...	...	...	...	...	...	...	...	652 0 3	
...	...	...	...	...	...	...	...	...	...	232 1 9	
...	...	...	...	...	...	...	...	...	...	146 2 3	
...	...	...	...	...	...	...	...	...	...	240 15 3	
...	...	...	...	...	...	...	...	...	...	129 3 3	
...	...	...	...	...	...	...	...	...	...	39 13 9	
...	...	...	...	...	...	...	...	...	...	262 7 9	
...	...	...	...	...	...	...	...	...	...	197 1 0	One subject not yet printed.
...	...	...	187	40	...	34	22,074	35	...	6,944 3 0	
...	...	...	...	...	...	1	2	...	...	1,220 3 6	Four subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	42 17 0	
...	...	...	...	...	...	...	...	...	...	18 0 0	
...	...	...	...	...	...	...	...	...	...	476 10 0	
...	...	...	...	...	...	...	...	...	...	894 12 6	
...	...	...	...	...	...	...	...	...	...	54 4 6	
...	...	...	269	...	...	3	3	...	...	420 4 9	
...	...	...	6	...	...	...	...	...	...	1,343 1 0	
...	...	...	...	...	...	...	...	...	...	15 12 0	
...	...	...	...	...	...	...	...	...	...	441 3 3	Four subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	818 6 0	Three ditto ditto.
...	...	...	...	96	...	...	...	...	...	3,806 1 0	
...	...	...	...	...	...	...	...	...	...	102 9 0	
...	...	...	66	...	...	...	...	...	...	125 1 6	
...	...	...	...	24	...	...	...	...	...	121 14 6	
...	...	...	178	...	...	1	706	...	...	393 7 6	
...	...	...	...	...	...	...	...	...	...	115 12 9	
...	...	...	...	...	...	...	...	...	...	216 9 0	
...	...	...	...	...	...	...	...	...	...	291 11 0	
...	...	...	...	...	...	...	...	...	...	115 2 0	
...	...	...	...	...	...	...	...	...	...	295 8 9	Two subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	2,764 15 6	Eleven ditto ditto.
...	...	...	...	...	...	...	...	...	...	279 0 6	
...	...	...	...	...	...	...	...	...	...	391 0 0	
...	...	...	...	...	...	...	...	...	...	96 0 0	
...	...	...	...	...	...	...	800	...	...	326 0 0	
...	...	...	...	...	...	...	...	...	...	121 0 6	
...	...	...	...	...	...	...	...	...	...	188 7 0	
...	...	...	...	...	...	9	3,462	...	...	474 15 6	
...	...	...	...	...	...	...	...	...	...	43 10 0	
...	...	...	...	...	...	...	...	...	...	176 6 6	
...	...	...	...	...	...	...	...	...	...	22 9 3	
...	...	...	748	286	...	54	30,699	35	...	53,103 6 9	

Statement of work done for other

Departments, etc.	Sheets or subjects.	Negatives and transparencies.	Photo-zincographic and Lithographic Printing.							
			Photo-transfer prints.	Zinc Plates transferred.	Zinc Plates printed.	Stones.	Pulls.	Number of Copies.		
								Colored.	Uncolored.	Total.
Brought forward	1,332	1,074	960	418	371	360	306,490	86,746	368,279	455,025
Private Secy. to Lieut.-Governor of N.-W. P. and Oudh	1	...	...	...	...	2	350	175	...	175
President, Municipal Committee, Naini Tal	6	5	6	1	...	...	...	...	...	...
Principal, Civil Engineering College, Seebpore	1	1	...	...	...	...	...	...	...	...
,, Medical Store-keeper to Government	1	1	1	1	1	...	104	...	104	104
Quarter-Master-General	58	58	57	38	63	24	12,071	1,820	13,119	14,939
Resident, Hyderabad Assigned Districts	...	...	...	...	...	1	20	...	20	20
Sanitary Commissioner, Assam	...	...	4	2	2	...	500	...	250	250
,, Bengal	6	...	...	2	2	7	4,956	3,060	1,274	4,334
,, India	9	6	...	...	...	4	1,270	...	1,570	1,570
,, Hyderabad Assigned Districts	2	1	1	...	...	1	200	...	200	200
Secretary to Lady Dufferin's Fund	1	...	1	...	...	2	3,030	1,515	...	1,515
Superintendent, Carriage and Wagons, B.B. and C. I. Ry	2	2	2	2	1	...	500	...	500	500
,, Emigration, Calcutta	4	...	...	...	...	8	2,308	2,154	...	1,154
,, Forest Surveys	1	...	...	...	...	5	50	10	...	10
,, Government Printing, India	49	2	2	3	5	26	18,452	...	26,369	26,369
,, Opium Agency	1	...	...	...	1	1	6	...	6	6
,, Presidency Jail	3	...	...	1	1	3	1,000	...	1,000	1,000
,, Stationery, Calcutta	13	...	...	...	...	13	9,600	...	9,600	9,600
,, Telegraph Stores	46	3	3	...	...	6	3,000	...	11,500	11,500
,, Zoological Gardens	...	...	...	...	...	...	...	...	...	...
Special work done for Trade and Private Individuals	81	10	10	8	14	2	22,646	...	16,646	16,646
Total	4,546	2,363	1,046	476	460	465	386,543	94,480	350,432	444,917

LITHOGRAPHIC OFFICE.

Departments, etc., during the year 1890-91—concluded.

Type Printing.			Silver and other Printing.			Heliogravure and Electrotyping.				Value.	Remarks.
Pages or items.	Pulls.	Copies.	Silver Prints.	Blue-Prints.	Miscellaneous Prints.	Heliogravure Plates.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.	£ s. d.	
...	...	...	748	286	...	54	30,699	35	...	53,103 6 9	
...	...	...	...	...	...	...	...	...	...	179 1 8	
...	...	...	...	...	...	...	...	...	...	62 6 6	
...	...	...	...	...	...	...	76	...	...	57 9 6	
...	...	...	...	...	...	...	...	...	...	14 1 6	
...	...	...	...	...	...	...	...	...	...	3,327 4 3	Two subjects not yet printed.
...	...	...	...	...	...	...	...	...	...	1 14 0	
...	...	...	...	...	...	...	...	...	...	89 8 0	
...	...	...	...	...	...	...	...	...	...	163 6 3	
...	...	...	...	...	...	3	706	...	...	510 13 0	
...	...	...	...	...	...	...	...	...	...	19 13 0	
...	...	...	...	...	...	...	...	...	...	88 5 6	
...	...	...	...	...	...	...	...	...	...	80 2 9	
...	...	...	...	...	...	...	...	...	...	214 0 0	
...	...	...	...	...	...	...	...	...	...	20 0 0	
...	...	...	...	...	...	...	...	...	...	2,316 5 6	
...	...	...	...	...	...	...	...	...	...	3 0 0	
...	...	...	...	...	...	...	...	...	...	73 14 9	
...	...	...	...	...	...	...	...	...	...	604 4 0	
...	...	...	...	...	...	...	...	...	...	442 12 6	
...	...	...	...	...	...	...	400	...	...	120 0 0	
...	...	...	348	...	...	...	...	...	...	1,152 3 3	
...	...	...	5,096	288	...	58	31,881	35	...	61,944 3 0	

MATHEMATICAL INSTRUMENT OFFICE.

TABLE A.

Detail of issues to, and receipts from, Provinces and Departments during the financial year 1890-91.

Provinces and Departments.	Receipts.	Issues.	Debits.	Credits.
	Value.	Value.	Value.	Value.
	R	*R*	*R*	*R*
Archæological Survey	...	70	70	
Assam	131	4,035	3,904	
Bengal, Civil	19,023	39,411	20,388	
,, Military	5,813	15,532	9,719	
Berar	...	555	555	
Bombay, Civil	50	3,030	2,980	
,, Military	61	1,095	1,034	
Burma	8,623	37,121	28,498	
Central India	1,325	2,665	1,340	
Central Provinces	...	6,800	6,800	
Forests	720	6,463	5,743	
Geological Survey and Museums	299	1,127	828	
Guaranteed Railways, E. I. Railway	...	284	284	
,, ,, Rajputana-Malwa Railway	...	158	158	
Land Revenue	691	3,252	2,561	
Law and Justice (Port Blair)	...	8	8	
Madras, Civil	1,581	17,305	15,724	
,, Military	3,053	1,930	...	1,123
Marine	726	1,085	359	
Medical	...	41	41	
Meteorological	268	1,913	1,645	
Mint	757	56	...	701
Military Works	339	7,399	7,060	
N.-W. Provinces and Oudh	11,423	10,383	...	1,040
Native States, Jaipur	1,097	1,006	...	91
,, ,, Ulwar	...	124	124	
P. W. D., N.-W. State Railway	860	2,526	1,666	
P. W. D., Coorg	...	270	270	
P. W. D., Baluchistan Railway Branch	957	22,458	21,501	
P. W. D., Baluchistan Ordinary Branch	149	1,520	1,371	
P. W. D., Hyderabad	...	5,680	5,680	
P. W. D., Rajputana and Central India	...	267	267	
P. W. D., Sind-Pishin State Railway	...	10	10	
Perso-Afghan Frontier (Khorassan)	...	829	829	
Political	...	372	372	
Post Office	...	4	4	
Punjab	7,625	26,252	18,627	
Secretariats, Government of India	1,557	8,660	7,103	
Survey of India	17,422	52,541	35,119	
Telegraph	116	585	469	
TOTAL	84,666	2,84,822	2,03,111	2,955
NET DEBIT	...	...	2,00,156	

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B.

Instruments, etc., purchased in the local market during 1890-91.

Instruments.	Number.	Value. R	a.
Barometers, aneroid, large	9	634	1
„ „ pocket	8	481	14
„ „ Watkins'	5	569	10
Boards, drawing, deal, large	2	24	0
Callipers, micrometer, small, parallel jaw	1	258	12
Clinometers, Watkins' pattern	12	226	8
Chain, measuring, iron, 30 feet	16	64	0
„ „ 66 „	50	256	0
„ „ 100 „	55	495	0
Compasses, beam, plain, 2 „	1	31	8
„ „ 3 „	1	21	11
„ „ with adjustment, 2 feet	4	144	0
„ „ „ „ 2½ „	6	224	4
„ bow divider, electrum spring	2	4	0
„ bow pens „ „	6	62	4
„ bow pencils, „ „ single jointed	1	3	8
„ „ „ „ spring	1	2	0
„ bow, sets	1	5	2
„ drawing, common, brass, 5-inch	966	1,025	12
„ „ „ 6 „	2	2	9
„ „ hair, „ 5 „	1	3	4
„ „ common, electrum, 5-inch	2	2	9
„ „ „ „ 6 „	1	2	8
„ „ hair „ 5 „	28	105	0
„ magnetic, pocket, in brass cases	19	222	12
„ „ „ „ electrum, cases	19	363	0
„ prismatic, card, 2½-inch	1	25	0
„ „ S. R., 2½ „	1	47	0
„ „ „ 5 „ and 6-inch	3	343	8
„ „ „ 4½ „	1	94	0
„ proportional, brass, 6-inch	18	204	8
„ „ electrum, 6 „	7	142	14
„ „ „ 9 „	10	347	10
„ triangular	2	94	8
Curves, French, large, set	1	4	0
„ railway or circular, small, set	1	12	8
„ „ „ wooden, sets, large and small	4	179	5
Declinometers	7	123	13
Glasses, binocular, large	1	27	9
„ „ small	5	201	11
„ copying or tracing	13	208	0
Girder testers	2	100	0
Glasses, time	2	9	0
Hydrometers with brass floats	80	3,182	5
„ „ glass „	20	324	12
Hygrometers, Masons'	1	9	14
Ghât tracers	16	770	15
Instruments, drawing, mathematical, electrum, 1st sort	12	794	4
„ „ „ „ 2nd „	3	85	2
„ „ „ „ 3rd „	28	515	15
„ „ „ in fish skin cases	3	112	0
Lenses, reading, ½-inch and 1-inch	100	50	0
„ „ 2½ „	6	11	13
„ „ 3 „ and 3½-inch	12	32	4
„ „ 4 „	6	21	6
Levels, field service	5	100	0
„ reflecting, Abney's	1	23	10
„ reversible, 12-inch	2	441	0
Machine, map printing, Ordnance pattern	6	255	0
Carried over	1,599	14,130	10

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B—*continued.*

Instruments, etc., purchased in the local market.

	Number.	Value. R	Value. a.
Instruments—continued.			
Brought forward	1,599	14,130	10
Magnets, horse-shoe, 3-inch	6	2	4
„ „ „ 6 „	5	7	8
Pens, drawing, common, ivory handles	226	407	8
Pins for maps, brass	1,649	87	9
„ „ electrum	2,052	158	5
Plane-tables, deal	16	153	8
Planimeters, electrum	2	87	8
Protractors, circular, cardboard, 5-inch	16	4	0
„ plain, circular, brass, 6 „	1	7	14
„ „ „ „ 9 „	1	14	10
„ with adjustment, semi-circular, brass, 6-inch	2	63	6
„ rectangular electrum, 6-inch	15	108	9
„ „ ivory, 6-inch	41	145	7
„ „ woooden, 6-inch	14	21	8
Pins for chains, common pattern	3 860	289	6
Rules, carpenters', boxwood, 2 feet, 2 fold	2	2	4
„ „ „ 2 „ 4 „	50	46	1
„ flat, ebonite, 6-inch	1	0	14
„ „ „ 1 „	265	174	2
„ „ „ 1½ „	1	1	8
„ parallel, bar, wooden, 6-inch	51	38	0
„ „ „ „ 12 „	1	1	0
„ „ „ „ 18 „	1	1	8
„ „ on rollers, brass, 12-inch	10	141	15
„ „ „ „ 18 „	1	23	10
„ „ „ electrum, 12-inch	1	23	10
„ „ „ „ 18 „	1	31	8
„ sight, wooden	275	825	0
Scales, architects', boxwood, sets	17	246	14
„ „ „ single	60	168	12
„ „ ivory, sets	1	47	4
„ „ „ single	3	47	7
„ diagonal, wooden	1,700	587	8
„ engineering, cardboard, single	84	89	4
„ Marquois, sets, wooden	8	44	0
„ offsets, single, ivory and slips	1,632	408	0
„ „ „ wooden	376	148	6
„ plotting, sets, ebonite	5	101	4
„ „ „ wooden	1	14	7
„ „ single, „	342	496	1
Sectioner, dead beat, Macginniss's	3	18	0
Sheets, celluloid	1,000	187	8
Slopes and batters, ebonite, single	14	12	4
Squares, optical	356	2,314	0
„ sets, ebonite, sets	12	88	14
„ „ „ single	38	37	0
„ „ wooden „	12	3	5
Sun-dials	4	80	0
Stands for levels, 12-inch	2	90	0
„ „ prismatic compasses	6	89	3
„ „ plane-tables, survey pattern	533	3,884	0
Stencil plates	46	67	5
T. squares, wooden, of sizes	6	34	8
Tapes, measuring, metallic, 25 feet and 33 feet	84	263	13
„ „ „ 50 „	60	255	4
„ „ „ 66 „	1	3	15
„ „ „ 24 „	13	48	12
„ „ „ 100 „	75	542	14
Carried over	15,060	27,420	4

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B—*concluded.*

Instruments, etc., purchased in the local market.

	Number.	Value.
		£ s.
Instruments—concluded.		
Brought forward	15,060	27,420 4
Tapes, measuring, steel, pocket, and others	62	860 10
Thermometers, spare, for hypsometers	12	99 12
„ clinical	12	60 15
„ maximum and minimum on same board, 9-inch	1	16 0
„ spare, for Syke's hydrometers	36	64 14
Watches, common	6	69 0
„ stop	2	150 0
Umbrellas, surveying	47	809 12
TOTAL	16,837	29,551 3
Books.		
Hints to Travellers	10	50 0
Manual of Surveying	2	24 0
Nautical Almanacs	179	270 4
Practical Physics	1	4 4
Tables for Barometrical Height, Mackesy	24	48 0
„ for Hydrometers, Casellas'	13	41 0
„ Log., Chambers'	24	66 0
Instructions for the use of Edmondson's Arithmometers	6	2 10
Tables, Log., Shortredes', with sines and tangents	25	500 0
Bruhn's Manual of Logarithms	16	57 9
Physical Optics	1	4 3
TOTAL	301	1,067 14
Sundries.		
Box for drawing instruments	1	2 8
Cards for marine compasses, mounted	1	9 0
Cases, leather	7	21 8
Canvas bags, waterproof lined	134	588 10
Glass ink bottles	24	3 2
„ jars for hydrometers	332	282 12
„ bottles for hygrometers	10	5 0
Havresacks	10	13 2
Horns, centre	24	4 0
Numbers for chain, iron, sets	2,000	562 8
Pencils, lead, for instruments	23	22 14
Telescopes for Watkins' range-finder	6	44 10
Trunks, mule, leather	6	87 0
Boxes for standard yard	62	62 0
Upper and lower cases for keeping type	2	10 0
Green umbrella covers	49	102 10
Rope, manilla	1,050	10 8
Water-gauge glasses	12	3 0
India-rubber rings	24	1 8
Screen for office	1	39 0
Opal glass reflector for Fortins' backboards	12	9 12
Excise ink bottles	12	1 12
Steel shots, $\frac{3}{16}$-inch	50	3 14
Brushes, stencils, medium size	21	7 3
Knives for instrument boxes	51	42 10
TOTAL	3,924	1,931 7
TOTAL OF BOOKS	301	1 067 14
TOTAL OF INSTRUMENTS	16,837	29,551 3
SUM TOTAL	21,062	32,550 8

MATHEMATICAL INSTRUMENT OFFICE.

TABLE C.

Instruments, etc., manufactured in the Mathematical Instrument Office during 1890-91.

	Number.	Value. £	s.
Instruments.			
Boards, drawing, deal, large	27	320	0
„ „ „ small	4	15	0
Chains, measuring, iron, 33 feet	7	15	12
„ „ „ 50 „	1	3	0
„ „ „ 66 „	1,087	3,657	0
„ „ „ 100 „	53	455	8
„ „ steel	18	156	0
„ „ other sizes and sorts	4	23	0
Clinometers, with hill shading scales and plummets	29	73	0
„ survey pattern	18	540	0
Combs, acre, cardboard	4,611	1,729	2
Compasses, magnetic, for plane-tables, 5-inch needles	130	1,585	0
„ „ „ „ 6 „ „	191	2,657	0
Glasses, copying or tracing	17	707	0
Girder testers	4	200	0
Hold-alls	36	633	0
Horizons, dark glass, plain	1	45	0
Level reflecting, Abney's	3	75	0
Machines, map printing, Ordnance pattern	6	315	0
Plane-tables, deal	397	2,865	8
„ „ „ military pattern	30	120	0
Pluviometers, Symon's pattern	200	1,666	0
Protractors, circular, cardboard, 12-inch	96	120	0
„ „ „ „ 5• „	306	76	8
Pins for chains, common pattern	1,900	116	8
„ „ Revenue Survey pattern	180	22	8
Rods, measuring, wooden	200	365	12
Rule, flat, ebonite, 1 foot	2	1	8
„ „ wooden, 1 „	200	37	8
„ parallel on rollers, brass, 18-inch	12	420	0
„ sight, wooden	37	341	0
„ „ brass, military	35	594	0
Scales, Bengali, metal	1	4	0
„ diagonal, cardboard	3,359	1,220	2
„ engineering, cardboard, single	1,295	249	1
„ offsets, sets, metal	1	6	0
„ „ „ wooden	40	7	8
„ „ single, cardboard	1,512	203	6
„ „ „ ivory and slips	125	46	14
„ „ „ wooden	402	109	12
„ plotting, single, wooden	3	4	2
Staves, cross or offsets	24	120	0
„ for omnimeters	18	450	0
„ „ subtense theodolites and compasses	9	225	0
„ levelling, telescopic, other pattern	1	23	0
Stamps for conventional sines and type-holders	12	80	0
Stands for plane-tables, survey pattern	44	734	0
Stencil plates	155	222	14
Yard, standard	251	1,255	0
TOTAL	17,100	24,848	13
Sundries.			
Boxes and cases, block tin and tin	5	15	0
„ deal-wood	2	5	0
Cases, leather	1	2	
Carried over	8	22	4

MATHEMATICAL INSTRUMENT OFFICE.

TABLE C—*concluded.*

Instruments, etc., manufactured in the Mathematical Instrument Office during 1890-91.

	Number.	Value. R	a.
Sundries—continued.			
Brought forward	8	22	4
Canvas bag, waterproof lined	8	35	8
Gauges writing	42	84	0
Glasses for pluviometers	164	395	8
Havresacks	7	13	4
Plummets, brass	54	137	0
Clamping screws for plane-tables	5	12	8
Squares, acre, horn	995	186	9
Traverse indicators	31	77	8
Water-gauge glasses	12	4	8
Packing rings for glasses	24	2	0
Cabinet stands for standard yard	2	60	0
Box, spare	1	2	8
Table	1	32	0
Steel punch	1	3	0
Seismoscope	1	32	0
Brass tube	1	3	8
Blanks for type	12	2	4
Screw-drivers	4	6	0
Talc square	1	0	3
Brass painter	1	2	8
Talc square, Bigah	200	28	0
Polariscope, circle, with stand	1	50	0
Box for stencil plates	1	2	0
Component parts of subtense staves	sets 4	80	0
Tin cases for plans	4	6	0
Boxes for scales	10	10	0
Pins for levels	16	3	0
Box for sight rules	1	1	0
Backboards for barometers	12	90	0
Zinc tickets for *khalásis*	166	7	12
Box for scale	1	1	0
Newar straps for boxes	2	3	0
Tin tube	1	0	12
Clasp for telescope	1	16	0
Camera lucida for telescope	1	10	0
Box, teakwood, for rule sight	1	1	8
Box, dealwood, with hinges and hasps	1	3	0
Surveyors' table, deal	1	20	0
Covers for umbrellas	3	6	0
Boxes for rule sight	2	2	0
Instrument for measuring Barograph scale	1	50	0
Zinc bottle for 5-inch Rain-gauge	1	2	0
Tin tube	2	3	0
Height Indicators	50	22	8
	50	25	0
Scales for Tide gauges	2	36	0
Wooden handles for rubber stamps	55	16	0
Scale attachment to Theodolite	1	107	6
Bubble spirit, 2-inch, mounted	1	3	8
Scale for testing Rain-gauge	2	11	0
TOTAL	1,969	1,731	14
TOTAL OF INSTRUMENTS	17,100	24,848	13
SUM TOTAL	19,069	26,580	11

MATHEMATICAL INSTRUMENT OFFICE.

TABLE D.

List of principal Instruments repaired in Workshop during the financial year 1890-91.

	Number.
Anemometers	27
Arithmometer	1
Bar lengthening	1
Barometers, of sorts	71
Board, drawing	1
Cases, sketching, leather	2
Chains, of sorts	48
Chronographs	5
Chronometers, of sorts	3
Chrono-micrometers	2
Circular calculating machine, Edmondson's	2
Clinometers, of sorts	20
Clocks, of sorts	3
Combs, acre	2
Compasses, bow dividers, spring, of sorts	4
„ „ pen, of sorts	52
„ „ pencil, of sorts	6
„ „ set	1
„ beam	3
„ drawing, of sorts	194
„ marine	9
„ magnetic, pocket	8
„ pillar	1
„ "Pelorus"	1
„ prismatic, of sorts	75
„ proportional	4
„ rectangular, of sorts	47
„ surveying, of sorts	64
Ghât tracer, with stand	1
Glasses, binocular	36
„ tracing	2
Hand-printing presses	8
Heliographs	44
Heliotropes	4
Hold-alls, leather	7
Hydrometers	117
Hygrometers	2
Instruments, drawing, mathematical, of sorts	45
Lamps, bull's-eye	1
Lenses, reading, of sorts	8
Levels, of sorts	89
„ reflecting	2
„ spirit	9
Machines, map printing, of sorts	4
Magnet bar	1
Microscopes	12
Pedometers	3
Pens, drawing, of sorts	115
Pencil legs, of sorts	3
Pentagraphs, of sorts	5
Pins for chains	230
Plane-tables, of sorts	4
Planimeters, of sorts	11
Pointers, station	2
Protractors, of sorts	9
Quadrant, gunners'	8
Quintant sounding	12
Rain-gauge, of sorts	25
Range-finders, of sorts	52
Recorders	2
Rules, of sorts	24
„ sight, for plane-tables, of sorts	48
Carried over	1,602

MATHEMATICAL INSTRUMENT OFFICE.

TABLE D—*concluded.*

List of principal Instruments repaired in Workshop during the financial year 1890-91.

	Number.
Brought forward	1,602
Scales, of sorts	3
Scotts' telescopic sights	10
Sextants, of sorts	6
Squares, optical	74
Stands of compasses, of sorts	33
„ heliographs	21
„ levels, of sorts	51
„ plane-tables	3
„ range-finders	5
„ theodolites	54
„ telescope	1
Station pointer	1
Staves, levelling, of sorts	79
Tapes, of sorts	270
Telescopes, of sorts	58
Theodolites, of sorts	120
Thermometers, of sorts	38
„ for hydrometers	22
„ for hygrometers	18
Tide-gauge, measuring apparatus	1
Watches, of sorts	3
TOTAL OF PRINCIPAL INSTRUMENTS REPAIRED	2,473
MINOR INSTRUMENTS REPAIRED	1,092
TOTAL OF ALL INSTRUMENTS REPAIRED	3,565

Profit and Loss account of the Workshop for the financial year 1890-91.

DEBITS.	R	a.	CREDITS.	R	a.
Workshop Establishment, less proportion debitable to the store branch for cleaning and adjusting serviceable instruments	36,767	3	By repairs for public officers	17,145	9
One-third of office establishment	2,416	13	„ „ for stock	22,770	6
Pay of Material Store-keeper for the whole year	780	0			
Workshop contingencies as distinguished from materials purchased	4,034	5	„ manufactures for stock—		
			Instruments	26,400	11
			Packing cases	1,412	2
Value of materials—					
For special work	26,815	13	Manufactures of materials	2,994	0
„ general workshop use					
„ manufacture of packing cases			Work on payment	1,346	3
Paid for repairs	11	6			
Wear and tear of plant	1,414	10	Loss	8,021	10
Half of rent at R600 per mensem	3,600	0			
Printing and stationery	576	7			
Four per cent. on value of tools and plant amounting to R91,849	3,674	0			
TOTAL	80,090	9	TOTAL	80,090	9

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Extract from the Narrative Report of MR. J. ECCLES, M.A., *in charge Computing Party, Season 1890-91.*

Lieutenant J. M. Burn, R.E., was appointed to do duty in this office on 10th May 1891, and was transferred on 30th September 1891 to No. 24 Party. Three temporary computers resigned during the year, and their places were filled by the appointment of new hands. One pressman for the Printing Section was appointed to work the large press received from Calcutta

The cost of the Computing Section under its various class-heads, and the percentages hereof with those of the two prior years, are given in the following statement:—

Class.	Cost in Rupees.	Percentage of Cost.		
	1890-91.	1890-91.	1889-90.	1888-89.
1. Records, Library	1,232	3	4	4
2. Accounts, returns, correspondence	2,226	5	5	3
3. Supply of data, &c.	475	1	2	4
4. Computations	10,176	74	71	69
5. Preparation of press copy	13,880			
6. Examination of press proofs	8,176			
7. Ditto of charts	1,936	4	1	1
8. Protection of stations	434	1	2	2
9. Miscellaneous	3,844	9	11	13
10. Meteorology and general science	658	2	2	3
11. Extra-departmental work	325	1	2	1
	43,362	100	100	100

It will be noticed that the percentages for classes 4, 5 and 6 contrast very favourably with those for the two preceding years, showing thereby that the working power of this section has been increased in its primary duties, that is, in the final reduction and publication of the results of the operations of the trigonometrical survey.

The following is an account of the work done under the various classes shown in the foregoing table:—

CLASS 1; RECORDS, LIBRARY, ETC.—The records have received the same care and attention as heretofore, and during the year five instalments have been received from field parties. There is nothing to add to the statement in last report regarding the work in connection with the Library, except that three copies of the catalogue have been kept up to date, each new work or periodical being entered by hand.

CLASS 2; ACCOUNTS, RETURNS, AND CORRESPONDENCE.—Under this head are included indents, estimates, monthly detailed and abstract progress reports, stock returns of ordnance stores, the compilation of data for the annual report, and various other items.

CLASS 3; SUPPLY OF DATA.—Requisitions from officers for data of various kinds have been complied with. In this class is also included the work in the despatch of maps, charts, books and forms.

CLASS 4; COMPUTATIONS.—These are given below in detail, but the computers' time has chiefly been taken up with the final reduction of the secondary work of the Southern Trigon, including Colonel Lambton's triangulation. The calculations were mostly of an intricate nature on account of the entanglement in very many places between the new and the old work, and it became a matter of considerable anxiety at one time to provide work for the Printing Section, as no press copy could be got ready without first completing the reduction; but by sub-dividing each section, and by judicious arrangement, this difficulty was obviated. The progress of the work is as follows:—

(1) The Mangalore Meridional series, finished.
(2) The South-East Coast series, finished.
(3) The Bombay Longitudinal series, finished.
(4) The Madras Meridional and Coast series, finished.
(5) The Madras Longitudinal series } about three-fourths completed.
(6) The Great Arc series }

A small catalogue, showing star-places, as deduced from the Latitude and Longitude observations of this Department, is in hand; two computers have been engaged on this work for four months.

The following help was afforded to field parties:—

Two computers were lent for three weeks to the Astronomical parties for the reduction of latitude observations of season 1890-91. Two computers were engaged for one month in preparing data for the survey officer who accompanied the Hazara Field Force. Two computers were engaged for one month in certain calculations in connection with Mr. Wainright's triangulation of season 1890-91 in Baluchistan, and that executed previously by Mr. Claudius.

Spirit-levelled heights for pamphlet No. 5, Bombay Presidency, and for No. 6, Madras Presidency, were revised.

The remaining work under this class was of a miscellaneous character.

CLASS 5; PREPARATION OF PRESS COPY.—This consists in abstracting and compiling the final results of the various calculations in a suitable form for publication: the copy so compiled is compared twice, both against the original field records and the final calculations before being sent to the press. The details of the work are as follows:—

(*a*) *South-West Quadrilateral.*—The descriptions of the principal stations of the Singi Meridional series were finally revised for the press, thus completing the remaining portion of Part II of Professional Volume XIV. The secondary triangulation belonging to the Quadrilateral could not be taken in hand on account of similar work of the Southern Trigon, which was urgently required to give work to the Printing Section.

(*b*) *Southern Trigon.*—Very considerable progress has been made with the compilation and comparison of the several tabular statements to be embodied in the Synoptical volumes. All those appertaining to the Mangalore Meridional and South-East Coast series have been entirely completed and passed for the press, and those for the Bombay Longitudinal, Madras Longitudinal and Madras Meridional and Coast series are well advanced. There only remains the Great Arc series, which cannot be taken in hand at present, the calculations being still incomplete.

(*c*) Letter-press for the preliminary chart of the Mandalay Meridional series, and for charts Nos. 56, 57, and 58 of the Burma Coast Triangulation, season 1889-90, has been revised and completed.

(*d*) The pamphlets of spirit-levelled heights, No. 5, Bombay Presidency and No. 6, Madras Presidency, were passed through the press.

(*e*) *Hand-Books of the Trigonometrical and Topographical Branches.*—The remaining portions of these two books were prepared, revised, and passed through the press.

(*f*) *Synoptical Volume XXII (Preliminary Issue).*—The co-ordinate list, pages 73 to 121, was revised: the preface, table of contents, errata, etc., were prepared and passed for the press.

(*g*) *Electro-Telegraphic Longitude.*—Two hundred and twenty pages containing observations and results of seasons 1885-86, 1887-88, and 1889-90 were examined and passed for the press.

(*h*) *Tidal Volume.*—A few chapters of the introduction have been compiled.

(*i*) *Burma Coast series.*—The alphabetical and numerical lists containing 142 principal stations have been prepared, and the observed angles at 20 stations arranged and numbered for printing: this had to be taken in hand to feed the presses which were running short of work.

CLASS 6; EXAMINATION OF PRESS PROOFS.—This consists in passing proofs, all requiring the utmost care in examination and comparison in the three stages of *first*, *second*, and *form* proof. As most of the matter printed is numerical or depends on numerical data, the examination can only be made by men who have been specially trained to this branch of the work.

The following works have been completed during the year:—

(1) Professional Volume XIV.
(2) Synoptical Volume XXII.
(3) " " XXIII.
(4) " " XXIV.
(5) Hand-book of the Trigonometrical Branch.
(6) " " Topographical Branch.
(7) Pamphlet of Spirit-levelled heights, No. 5, Bombay Presidency.
(8) " " " No. 6, Madras Presidency.
(9) Two exploration reports (reprint).

Nos. 1, 5, 6, 7, 8, and one of 9 have been bound and issued, and the others are in the hands of the binder, and will shortly be ready for issue.

CLASS 7; EXAMINATION OF CHARTS.—The following charts were examined and passed for the press:—

(1) Preliminary chart, Mandalay Meridional series } Season 1889-90.
(2) Three preliminary charts of Bombay Coast Triangulation }
(3) Final charts for Synoptical Volumes XXII, XXIII, and XXIV.
(4) Two Level charts for Pamphlets of spirit-levelled heights.

In addition four rough working charts for Synoptical volumes of the Bombay and Madras Longitudinal series were prepared, without which the compilation of the tabular details of these volumes would have been very materially delayed.

CLASS 8; PROTECTION OF STATIONS.—The usual professional aid in connection with the protection of survey stations has been rendered by the Computing Section to the office of the Deputy Surveyor General. During the year 416 stations have been repaired by District Officers at a cost of ₹1,448-14-6. Twenty-eight districts out of 334 from which reports are due failed to submit them.

CLASS 9; MISCELLANEOUS.—In this class are included various duties which cannot fairly be assigned to any of the other classes, such as the following:—

(*a*) the taking and reducing of time observations at Mussooree and giving the signal for the 12 o'clock gun;

(*b*) the preparation of examination papers for the Senior and Junior Divisions of the Survey of India Department, and the examination of 33 sets of such papers, one being for the Senior Division;

(*c*) the examination and despatch of printed papers to the Survey of India Office for safe custody, and of printed pages of Professional and Synoptical volumes to Roorkee and Calcutta for binding, etc., etc.

CLASS 10; METEOROLOGY AND GENERAL SCIENCE.—A complete set of meteorological observations was taken daily throughout the year, and monthly abstracts prepared. The results are given in the following statements.

CLASS 11; EXTRA-DEPARTMENTAL WORK.—Two computers were engaged for two months for the Quarter Master-General's Department in reducing astronomical, barometrical, and hypsometrical observations taken in Persia and elsewhere.

MEAN MONTHLY READINGS OF EARTH THERMOMETERS.

Depth in feet of Thermometer bulbs below surface of ground.	Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
25·6	1890-91	77·42	77·26	77·04	76·68	76·68	75·42	74·78	74·26	74·46	74·25	74·70	75·47
	Mean 1881—90	76·73	76·83	76·60	75·83	75·25	74·66	74·69	74·09	73·99	74·33	75·40	76·51
12·8	1890-91	79·56	78·81	76·91	74·72	72·71	71·05	70·72	72·89	74·40	76·36	77·84	78·72
	Mean 1881—90	79·39	77·83	75·32	72·59	71·00	70·54	72·40	73·20	75·24	77·10	79·07	79·68
6·4	1890-91	79·58	75·87	71·73	68·10	65·61	65·60	69·38	75·33	79·21	81·56	81·03	80·78
	Mean 1881—90	79·72	75·60	70·86	66·97	65·41	67·44	71·74	76·30	80·06	81·11	81·36	81·24
3·2	1890-91	77·47	70·97	65·69	62·13	59·96	63·35	72·61	80·68	84·13	84·36	81·62	81·27
	Mean 1881—90	78·28	71·66	65·43	61·81	61·35	67·36	75·48	81·55	84·62	83·17	82·16	81·69
1·1	1890-91	74·91	66·71	59·28	56·82	53·48	61·88	75·40	83·59	88·23	85·51	81·63	80·92
	Mean 1881—90	76·31	67·52	60·32	57·48	58·77	68·42	79·10	85·82	88·08	83·94	82·59	81·81
Thermometer in shade.	1890-91	80·17	73·10	67·04	64·30	62·79	72·11	88·53	92·81	94·90	85·46	79·89	80·30
	Mean 1881—90	81·19	73·91	68·74	64·45	68·07	79·28	89·89	93·33	90·75	82·21	80·90	82·79

Mean velocity in miles of the Winds which blew at Dehra Dun during the twelve months of 1890-91 for each hour of the day.

Civil Hours.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Mean.
0 to 1 . .	0·58	1·73	0·50	0·58	0·61	1·42	1·72	1·29	1·83	0·66	0·71	0·80	1·04
1 „ 2 . .	0·42	1·47	0·47	0·81	0·71	1·32	1·66	1·29	1·63	0·90	0·43	0·77	0·99
2 „ 3 . .	0·45	1·13	0·50	0·71	0·39	1·52	1·31	1·03	1·63	0·72	0·57	0·83	0·90
3 „ 4 . .	0·26	0·77	0·67	0·61	0·57	1·26	1·55	0·94	1·47	1·07	0·46	0·53	0·85
4 „ 5 . .	0·16	0·97	0·77	1·16	0·54	1·19	1·45	0·71	1·00	1·03	0·43	0·53	0·83
5 „ 6 . .	0·13	0·97	0·53	0·68	0·54	1·29	0·90	0·81	0·60	0·86	0·57	0·57	0·70
6 „ 7 . .	0·23	0·43	0·57	0·77	0·89	1·23	1·00	0·87	0·57	0·66	0·68	0·67	0·71
7 „ 8 . .	0·19	0·43	0·60	0·84	0·86	1·16	1·07	0·90	0·77	0·69	1·04	0·43	0·75
8 „ 9 . .	0·07	0·33	0·40	0·68	0·86	1·42	1·27	1·23	0·87	1·14	1·04	1·03	0·86
9 „ 10 . .	0·10	0·77	0·73	0·87	1·71	1·94	1·77	1·97	1·37	1·52	1·54	1·37	1·31
10 „ 11 . .	0·52	1·28	0·67	1·42	2·29	2·39	2·23	2·80	1·90	1·73	1·55	1·97	1·73
11 „ 12 . .	0·71	1·79	1·30	1·65	2·32	3·23	2·63	3·30	2·53	1·97	1·86	1·83	2·09
12 „ 13 . .	0·81	1·47	1·55	1·74	2·36	3·68	3·17	3·30	2·73	2·03	2·32	2·10	2·27
13 „ 14 . .	0·90	1·90	1·52	1·77	3·70	4·26	3·72	4·40	3·33	2·76	2·64	2·21	2·76
14 „ 15 . .	0·74	2·00	1·83	2·39	4·14	3·77	3·76	4·20	3·80	2·90	2·64	2·21	2·87
15 „ 16 . .	0·77	1·57	1·24	2·03	3·54	3·90	3·93	4·10	3·57	2·41	2·18	1·86	2·59
16 „ 17 . .	0·32	0·50	0·53	1·90	2·54	4·42	3·62	4·00	3·13	1·90	2·46	1·69	2·25
17 „ 18 . .	0·03	0·17	0·37	0·68	1·21	2·48	3·24	3·84	2·73	1·31	1·43	1·14	1·55
18 „ 19 . .	0·07	0·67	0·53	0·55	1·07	1·42	1·21	2·55	1·83	1·10	0·71	0·93	1·05
19 „ 20 . .	0·81	1·43	0·90	0·48	1·18	1·07	1·52	2·16	0·73	0·76	0·39	1·31	1·06
20 „ 21 . .	0·48	2·07	0·87	0·71	0·89	1·52	1·83	2·29	0·93	0·76	0·57	0·90	1·15
21 „ 22 . .	0·61	2·13	0·90	0·68	0·96	1·74	1·86	2·26	1·23	0·76	0·75	0·72	1·22
22 „ 23 . .	0·61	2·13	0·93	0·61	1·07	1·71	1·66	2·00	1·87	0·66	0·79	0·86	1·24
23 „ 24 . .	0·77	1·87	0·83	0·68	1·04	1·81	1·72	1·52	1·63	0·76	0·68	0·93	1·19
Sums . . .	10·74	29·98	19·71	25·00	35·99	51·15	49·80	53·76	43·68	31·06	28·44	28·19	...
Average . .	0·45	1·25	0·82	1·04	1·50	2·13	2·08	2·24	1·82	1·29	1·19	1·17	...

Monthly Meteorological Results of Observations taken at the Office of the Trigonometrical Branch, Survey of India, Dehra Dun.

Year and Month.	Barometer reduced to 32° Fahrenheit.						Hygrometer.		Thermometer.				Rain.		Wind.	Cloud.	
	At 10 A.M.			At 4 P.M.			At 10 A.M.	At 4 P.M.	Dry Bulb.			Wet Bulb.					
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean humidity.	Monthly mean humidity.	Maximum in air.	Minimum in air.	Monthly mean in air.	Minimum.	Number of days it fell.	Fall in inches.	Most frequent direction.	At 10 A.M.	At 4 P.M.
1890.																	
October	27·810	27·543	27·703	27·736	27·490	27·618	60	48	85·6	52·7	69·8	49·0	3	0·34	Calm	1	1
November	·905	·717	·818	·813	·658	·732	54	42	78·9	46·2	62·0	41·9	*Nil*	*Nil*	,,	2	3
December	·917	·717	·795	·888	·630	·712	67	50	76·3	40·8	56·8	38·8	5	1·64	,,	4	5
1891.																	
anuary	·887	·634	·797	·816	·618	·718	74	52	74·2	39·7	55·4	40·2	6	3·06	,,	4	5
February	·996	·555	·760	·914	·455	·694	61	44	74·5	35·4	53·3	33·9	6	2·37	,,	5	6
March	·769	·562	·693	·737	·425	·612	48	38	83·3	46·6	61·7	43·1	6	1·68	W	3	5
April	·717	·532	·609	·631	·387	·520	33	23	95·3	56·7	75·4	51·1	2	0·25	WNW	4	4
May	·651	·358	·525	·616	·276	·437	32	24	100·0	60·3	80·6	56·0	4	1·30	,,	2	4
June	·518	·271	·389	·405	·187	·308	42	33	103·1	67·6	84·3	57·1	4	3·69	,,	2	2
July	·477	·203	·346	·412	·113	·264	73	67	99·7	67·1	80·3	61·3	19	13·08	SSE	6	6
August	·578	·278	·455	·494	·232	·379	83	84	89·8	68·5	75·8	68·3	23	18·46	,,	8	8
September	·678	·443	·564	·572	·366	·473	80	80	87·2	67·9	75·6	65·8	14	7·45	,,	7	8

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

TYPE-PRINTING SECTION.—With the exception of a trifling amount of work done for other departments, the energies of this section have been entirely devoted to the publication of the records of this branch of the Survey Department and work connected with the office.

For many years the forms for use with the Tidal and Levelling Party were procured elsewhere, but now a portion of them are printed in this office, and this has thrown a good deal of extra work on the Type section. In order to increase the press power of the branch, a press has been transferred from the Calcutta Office, and in the hands of a suitable pressman is now found quite equal to meet the extra demand.

Statement of Departmental work done during the year 1890-91.

SPECIFICATION OF PRINT.	Number of pages.	Total number of pulls.	Number of copies.	Value.
				₹
Professional Volumes	479	62,680	510	7,089
Synoptical	252	26,105	360	3,600
Pamphlets of spirit-levelled heights	77	5,520	310	846
Letter-press for charts, map headings and foot-notes	78	1,510	...	285
Hand-books for the Trigonometrical and Topographical Branches	313	8,745	154	3,189
Forms	239	60,296	...	2,007
Exploration Reports (reprints)	128	3,180	100	1,390
Extra-Departmental	32	1,302	...	103
TOTAL	1,598*	169,338	...	18,509

* Equal to 2,165 pages of standard (foolscap) size.

The usual table showing the work annually performed by this section during the past five years is given below, the unit (a page of foolscap) being the same throughout.

	1886-87.	1887-88.	1888-89.	1889-90.	1890-91.
Pages composed	1,516	1,994	1,989	1,998	2,165

An analysis of the pages composed is as follows :—

		PAGES
PROFESSIONAL VOLUMES	Bombay Longitudinal Series	6
	South-East Coast Series	6
	Introductory chapters	106
	Singi Meridional Series	25
	Kattywar Meridional Series	89
	Abu Meridional Series	9
	Gujarat Meridional Series	18
	Cutch Coast Series	92
	Longitude operations	415
	Burma Coast Series	39
	TOTAL	805
SYNOPTICAL VOLUMES	South Konkan Coast Series	25
	Mangalore Meridional Series	184
	South-East Coast Series	54
	Madras Longitudinal Series	28
	Assam Valley Series	112
	TOTAL	403
MISCELLANEOUS	Exploration reports (reprint)	170
	Hand-books for Trigonometrical and Topographical Branches	313
	Spirit-levelled Heights	76
	Letter-press for Charts, map headings and foot-notes	33
	Forms, Orders, Memoranda, etc.	333
	Extra-Departmental	32
	TOTAL	957

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

PHOTO-ZINCOGRAPHIC SECTION.—This section has been employed in printing maps charts, diagrams, etc., both to illustrate the volumes published by the office and for general use; also in printing from zinc the departmental professional forms in which mathematical formulæ are largely employed: it has also executed a large amount of extra-departmental work, as will be seen on reference to one of the following tables; about one-third the work done has been for other departments.

The following statements exhibit the value and out-turn of work done in this section:—

Statement shewing the Amount and Value of work done for other Departments, etc., during the year 1890-91.

DEPARTMENTS, ETC.	PHOTO-ZINCOGRAPHIC PRINTING.								Value.	REMARKS.
	Sheets or sections or subjects.	Negatives.	Photo-transfer Prints.	Zinc Plates.	Silver Prints.	Blue Prints.	Pulls.	Copies.		
									R. a.	
Foreign Department . .	1	7	7	1	...	...	60	60	88 14	
Forest ditto . .	63	269	263	57	100	460	3,413	3,421	3,696 2	
Military ditto . .	5	16	22	3	...	...	65	252	315 2	
Quarter Master General .	6	15	35	6	...	...	93	335	416 0	
Miscellaneous . . .	2	6	6	2	...	...	...	...	67 3	
Cash sale	...	...	...	...	...	...	...	...	459 0	
TOTAL . .	77	313	333	69	100	460	5,060	4,068	5,042 4	

Statement of Departmental Work done during the year 1890-91.

Specification of Plate or Print.	Photo-zincographic Printing.											Remarks.
	Progress made.	Scale of map.	Size of each sheet.	Sheets or subjects.	Negatives.	Photo-transfer prints.	Zinc plates.	Silver prints.	Blue prints.	Pulls.	Copies.	Value.	
												₹	
Abstract of horizontal angles and approximate azimuths, etc. (Colonel Tanner's)	F.	...	½ Im.	1	...	...	...	...	...	206	206	25 12	
Arabia and Persia, Map of Part of Nos. 1 and 2	* F.	32	D. E.	2	...	...	...	...	...	150	150	36 12	
Assam Valley Triangulation, Index to Degree Sheets	F.	16	½ D. E.	1	4	4	1	...	...	110	110	59 4	For Synoptical Volume XXII.
Burma Coast, Preliminary Chart, Nos. 56, 57 and 58	F.	2	D. E.	3	20	20	3	...	...	186	186	272 4	
Central Provinces Survey, Sheets Nos. 12 S.E./2, S.E./4; 13 N.E./2; 19 N.E./1, N.E./2, N.E./3, N.E./4, N.W./4, S.E./2, S.E./4, S.E./1&2, S.W./1, S.W./2, S.W./3; 20 N.W./1, N.W./3; 19 S.E./3 and 20 N.E./1 (in one); 19 S.W./4 and 20 N.W./2 (in one); 26 N.W./3, S.W./1&2, and S.W./3&4.	F.	¼	D. E.	21	118	130	21	...	...	3,156	3,156	2,057 15	
Chart showing the Triangulation between Ibrahimabad and Kushan for the purpose of fixing the longitude of Kushan	F.	25	⅛ D. E.	1	...	...	...	...	..	162	324	17 14	For Hand-book, Topographical Branch.
Clinometer, Height Indicator (Captain Wahab's)	* F.	...	⅛ D. E.	1	...	...	...	...	...	26	156	8 10	
Curve showing the Graduation of Errors of T. and S's 12″ Theodolite No. 1	F.	...	½ D. E.	1	1	...	...	...	...	...	...	5 11	
Dehra Dun and Siwaliks Survey, Index map	* F.	4	½ D. E.	1	2	4	1	...	...	30	60	40 2	
Eastern Frontier Series, Preliminary Chart, 1866-67 (in two parts)	* I.	4	D. E.	2	12	...	...	...	...	...	...	68 7	
Forms for Departmental use (Miscellaneous)	F.	...	...	21	14	63	17	...	...	2,475	2,324	736 1	
Do. do. do. (Professional)	F. & I.	...	...	24	7	132	29	...	...	10,181	11,043	1,986 6	
Gujarat Survey, Sheets Nos. 6, 11, 12, 13, 16, 25, 29, 30, 33, 34, 49, 49 (portions of Sections 2, 4 and 5) and 76	* F. & I.	1	D. E. and 1/16 D. E.	15	43	99	11	12	...	686	698	935 5	
Hazara Expedition, 1891 (Preliminary issue)	* F.	½	D. E.	1	4	4	1	...	...	182	182	86 13	
Hundes or Narikhorsun and Monyul (in two parts)	* F.	8	D. E.	2	9	18	2	...	...	100	50	165 14	
Jaunsar and Bawar Survey, Sheets Nos. I, II, III and IV	* F.	½	D. E.	4	18	18	3	...	...	240	240	267 9	
Karwar Port, Diagram	I.	½	½ D. E.	1	1	2	1	...	...	4	8	16 7	For Professional Volume.
Do., Map (portion of)	I.	½	½ D. E.	1	1	4	1	...	...	2	8	31 8	
Do., Tidal Curves at	I.	...	½ D. E.	1	1	1	1	...	...	12	12	13 11	
Kattywar Survey, Sheets Nos. 8, and 2nd Edition of 10, 11, and 20	* F.	1	D. E.	4	19	37	4	...	...	252	252	355 4	
Khánpisura Meridional Series, Rough Chart	F.	4	D. E.	4	25	25	4	...	...	88	44	311 10	
Kohat Topographical Survey, Triangulation Chart, 1880—83	* F.	4	D. E.	1	6	6	1	...	...	30	30	75 7	
Kumaun and Garhwál Survey, Sheets Nos. 1, 2, 7, 9, 17, 18 and 24	* F. & I.	1	D. E.	8	18	30	5	...	...	403	403	353 15	

Lhasa, Plan of, by A—K	* F.	4	½ D. E.	1	6	6	1	...	...	105	105	81 5	For reprint of Exploration Report.
Mandalay Series, 1889-90, Preliminary Chart of principal Triangulation	F.	4	D. E.	1	6	6	1	...	...	60	60	83 11	
Mandalay Series, 1889-91, Preliminary Chart of principal Triangulation	F.	4	D. E.	1	8	8	1	...	...	60	60	104 2	
Mangalore Meridional Series, Final Chart (in two parts)	F. & I.	32	D. E.	2	16	24	4	...	...	366	366	273 10	For Synoptical Volume XXIV.
Mirzapur Survey, Sheet No. 185 S.E.	F.	½	D. E.	1	6	6	1	...	...	150	150	99 7	
Mussooree and Landour, Guide Map	* I.	½	D. E	1	...	8	1	...	...	...	...	42 0	
N. E. Quadrilateral of the G. T. S. of India, Diagram	F.	16	½ D. E.	2	2	6	2	...	...	241	482	69 14	For Synoptical Volumes.
N. E. T. Frontier, Sheets Nos. 6, 7, 7 N.W. $/\frac{N.W.}{1}$, and part of 6 $\frac{S.W.}{3}$ (in one), and $\frac{N.W.}{3}$	* F. & I.	¼, ½, 2&8	D. E.	6	1	38	5	...	...	270	270	276 15	
Punjab Survey, Sheets Nos. 246 (N.E.) 1, (N.E.) 2 (N.E.) 3, (N.E.) 4, (N.W.) 4, (S.E.) 1; 285 (N.W.) 1, (N.W.) 2, (N.W.) 3; 310 (N.E.) 1 and 2.(N.E.) 2, (N.E.) 4, (S.E.) 4; 332 (N.W.) 1, (N.W.) 2, (N.W.) 3, (N.W.) 4, (S.W.) 1 and (S.W.) 3	F. & I.	½, ½ & 1	½, ¼, and D.E.	26	117	152	16	27	...	342	423	1,344 9	
Singi Meridional Series, Rough Chart	F.	...	½ D.E.	1	3	18	...	...	...	...	6	27 14	
Skeleton Chart of the Principal Chains of Triangles west of the meridian of 92°, Diagram	F.	...	½ D. E.	1	1	2	1	...	...	260	520	48 10	For Professional Volume XIV.
Specimen of Hill shading	F.	...	¼ D. E.	1	1	2	1	...	...	30	60	14 0	For examination of candidates for Junior Division.
Spirit-levelling Operations, No. 6 Madras Presidency and No. 5 Bombay Presidency	F.	16	½ D. E.	2	4	8	2	...	...	329	658	109 6	For Pamphlets of Spirit-levelled heights.
S. Trigon. of the G. T. S. of India, Diagram	F.	...	½D. E.	1	1	8	2	...	...	620	2,480	138 15	For Synoptical Volumes.
S. W. Asia, Sheet No. 72	* F.	8	D. E.	1	...	...	...	...	...	75	75	18 6	
S. W. Quadrilateral of the G. T. S. of India, Reduction Chart of principal Triangulation	F.	24	D. E.	1	9	18	2	...	...	515	515	210 6	For Professional Volume XIV.
Tibet, Revised map (Mr. Paul's)	* F.	16	½ D. E.	1	...	...	...	...	...	20	10	7 0	
Trans-Himalayan exploration map No. 11, by Mullah, 1876	* F.	12	½ D. E.	1	...	...	...	...	...	52	52	7 8	
Do. do. No. 15, by A—K, Nos. 1 to 3 (revised).	* F.	16	D. E.	1	18	18	3	...	...	315	315	252 0	For Reprints of Exploration Reports.
Do. do. do. Index	* F.	...	D. E.	1	6	6	1	...	...	105	105	84 0	
Turkistan, map, Nos. 1, 2, 3 and 4 (6th edition)	* F.	32	D. E.	4	...	28	4	...	...	240	240	216 0	
Do. do. Index	* F.	...	½ D. E.	1	...	2	1	...	...	15	30	9 8	
Other maps, for office use, Surveyor General's Office, etc.	F. & I.	...	...	47	114	172	34	...	3	5,376	2,660	2,684 1	
COPIES OF MAPS OF OTHER DEPARTMENTS TAKEN FOR DEPARTMENTAL USE, 1890-91.													
Anglo-Siamese Boundary Commission, 1890-90 (Preliminary Map)	F.	12	D. E.	..	...	...	...	...	...	...	...	17 12	
Berar Forest Survey, Sheets Nos. 13 N. E., $\frac{N.E.}{1}$, $\frac{N.E.}{2}$, S. E.; 14 N. E., $\frac{N.W.}{3}$; 13 S. W. and 14 N. W. (in one); 19 $\frac{N.E.}{1}$, $\frac{N.E.}{2}$, $\frac{N.W.}{2}$, $\frac{N.W.}{3}$, $\frac{S.W.}{1}$, $\frac{S.W.}{3}$, N. W. and S. W. (in one); 20 $\frac{N.W.}{2}$; 20A N. W.; 26 $\frac{N.W.}{1}$, $\frac{N.W.}{3}$ and $\frac{S.W.}{1}$	F.	½ & ¼	D. E. & D. E.	23	14	81	19	...	490	345	345	110 6	

Statement of Departmental Work done during the year 1890-91—contd.

Specification of Plate or Print.	Photo-zincographic Printing.											Remarks.
	Progress made.	Scale of map.	Size of each sheet.	Sheets or subjects.	Negatives.	Photo-transfer prints.	Zinc plates.	Silver prints.	Blue prints.	Pulls.	Copies.	Value.	
												R a.	
Burma Forest Survey, eight circles	F.	1	½ D. E., ½ D. E., ½ D. E.	8	4	4	1	...	...	160	160	23 6	Copies retained for office record, of maps, etc., requisitioned for by other departments, the cost of press pulls and stationery being all that is here charged to the Survey Department; the numbers in columns 5 to 8 therefore stand excluded from the totals.
Burma (Upper), Kindat; Taungawin with parts of Mingin, Kani and Se-Yaw-Gyaung; and Yu Reserves	F.	1	D. E.	3	18	18	3	...	...	45	45	15 12	
Burma (Upper), Map of the Sariekta, Nankyita and Nanbyen forests, Kaulia range, Yeu and Wuntho Districts	F.	1	D. E.	...	...	...	...	...	...	15	15	6 6	
Central Provinces, Index to the Forest Survey, District Bhandara	F.	8	½ D. E.	...	...	...	...	...	...	...	...	3 14	
Chamba State, Leased Forests	F.	½ & 2	½ D. E. & D. E.	3	1	10	2	...	...	55	35	13 7	
Chota Nagpore Forest Survey, Sheets Nos. 125 $\frac{\text{S. E.}}{1 \& 3}$, $\frac{\text{S. E.}}{2 \& 4}$; 126 $\frac{\text{N. E.}}{1}$, $\frac{\text{N. E.}}{2}$, $\frac{\text{N. E.}}{3}$, $\frac{\text{N. E.}}{4}$, $\frac{\text{N. W.}}{2}$, $\frac{\text{N. W.}}{4}$, $\frac{\text{S. E.}}{1}$, $\frac{\text{S. E.}}{2}$; 127 $\frac{\text{S. W.}}{4}$ and 157 $\frac{\text{N. W.}}{3}$	F.	½	D. E.	13	12	37	6	...	...	195	195	82 14	
Jaunsar Division, Korwa Forest, Bamtar Khat	F.	1½	½ D. E.	...	...	...	...	...	...	...	...	4 3	
Kheri and Pilibhit, Map of the Reserved Forests	F.	4	½ D. E.	...	...	...	...	...	...	...	...	2 12	
Naini Tal, Geological map	F.	¼	½ D. E.	...	...	...	...	...	...	...	...	1 14	
Punjab Forest Survey, Bushahr State, Sheet No. 332 $\frac{\text{N. W.}}{3}$	F.	½	D. E.	1	...	...	...	...	...	...	...	6 6	
Other maps	F.	...	...	6	15	17	3	...	...	395	265	67 2	
Total	...	...	...	226	642	1,133	189	39	493	29,437	30,344	14,487 14	

* Additional prints of previous publications; Im. represents Imperial; D. E. represents double elephant; F. represents finished; I. represents in press.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

SOLAR PHOTOGRAPHIC SECTION.—This section has no real connection with the work of this office; but was established at Dehra as a matter of convenience, so that it might be under suitable supervision without expense to Government.

In addition to the ordinary daily routine of photographing the sun, some photographs were obtained of the passage of Mercury across the sun's disc on the morning of 10th May, so timed as to secure the planet at the moment of internal contact at egress.

Table of working facts for the year 1890-91.

1890-91.	Number of Days.				Number of Negatives.										Number of working days when Solar Phenomena were	
		Failures			Solar Phenomena.								Total.			
	When negatives were taken.	From bad weather.	From various causes.	Total.	Spots and Faculæ.		Spots only.		Faculæ only.		None.				Visible.	Absent.
					8″	12″	8″	12″	8″	12″	8″	12″	8″	12″		
October	31	...	...	31	33	...	...	...	24	...	...	...	57	...	31	...
November	26	4	...	30	23	...	...	...	18	...	5	...	46	...	23	3
December	26	5	...	31	30	...	...	...	14	...	...	...	44	...	26	...
January	24	7	...	31	23	...	...	...	20	...	...	...	43	...	24	...
February	20	8	...	28	28	4	...	...	9	...	...	...	37	4	20	...
March	27	4	...	31	37	...	...	...	9	...	...	...	46	...	27	...
April	28	2	...	30	49	...	...	...	...	...	...	...	49	...	28	...
May	30	1	...	31	55	7	...	...	...	...	...	...	55	7	30	...
June	30	...	...	30	54	...	...	...	...	...	...	...	54	...	30	...
July	22	9	...	31	35	...	...	...	...	...	...	...	35	...	22	...
August	18	13	...	31	26	...	...	...	2	...	...	...	28	...	18	...
September	21	9	...	30	33	...	...	...	...	...	...	...	33	...	21	...
TOTAL	303	62	...	365	426	11	...	...	96	...	5	...	527	11	300	3

Seven hundred and thirty-four silver prints of the 8-inch, and twelve of the 12-inch pictures were prepared, and weekly despatches of both silver prints and negatives made as usual to the India Office.

Table contrasting visibility of sun at Dehra Dun and Greenwich.

Year.	At Dehra Dun.			At Greenwich.		Remarks.
	Number of days on which negatives were taken.	Percentage of days on which negatives showed features.	Number of days when sun was invisible.	Year.	Number of days on which negatives were taken.	
1880-81*	307	96	55	1880	156	* From 1st October to 30th September following.
1881-82	328	100	37	1881	181	
1882-83	318	100	47	1882	221	
1883-84	285	100	78	1883	215	
1884-85	284	100	81	1884	154	
1885-86	290	100	75	1885	206	
1886-87	302	98	61	1886	199	
1887-88	328	91	38	1887	188	
1888-89	315	71	50	1887-88	205	† Year ending 10th May 1889. Obtained from Report to the Board of Visitors.
1889-90	320	78	45	1888-89†	182	
1890-91	303	99	62	1889-90	Not obtainable.	
Means	307	...	57	...	191	

DRAWING SECTION.—The details of the work done in this section are given in the tables which follow:—

Statement showing the value of work done for other Departments, etc., during the year 1890-91.

Departments, etc.	Value.
	R a.
Quarter Master General's Department	132 0
Forest Survey Office	78 8
Director, Geological Survey of India	30 8
Deputy Commissioner, Simla	4 0
TOTAL	245 0

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

DRAWING SECTION.

Statement showing work performed during the year 1890-91.

Title.	Number of Sheets.	Scale. In. M.	Remarks.
General Maps.			
Exploration map	2	1 = 16	Final press order given.
Ditto	1	1 = 32	Corrected. Final press order given.
Expedition Survey map	1	1 = 2	Ditto. Ditto.
Ditto	1	2 = 1	Ditto. Ditto.
Miranzai Expedition Survey map, April-May 1891	1	1 = 1	Completed. Ditto.
Standard Maps.			
North-Western trans-Frontier series—			
One map (3rd Edition)	1	1 = 4	Final press order given.
Three maps	3	1 = 4	Completed. In press.
Kumaun and Garhwal Survey Sheet No. 17	1	1 = 1	Corrections made for reprints. Final press order given.
Central India and Rajputana Topographical Survey, Sheet No. 260 (2nd Edition)	1	1 = 1	In hand.
Gujarat Survey, Sheet No. 30	4	2 = 1	Corrected for reprints. In hand.
Ditto No. 29	4	2 = 1	Ditto. Final press order given.
Punjab Survey, Sheets	12	4 = 1	Corrected the preliminary edition. Final press order given.
Ditto	4	4 = 1	Corrected for reduction to ½ scale. In press.
Central Provinces Survey, Sheets	15	4 = 1	Corrected and completed. Final press order given.
Index Maps.			
For Annual Administration Report	4	Various	Corrected to date and sent to press.
Degree Sheets of Assam Valley Triangulation	1	1 = 16	Prepared on a copy of the map of Assam for Synoptical Volume. Preliminary issue. Final press order given.
Spirit-Levelling Operations in Bombay Presidency	1	1 = 16	Corrected. Drawn on double the scale for reduction to one-half for Pamphlet No. 5, Bombay Presidency. Final press order given.
Spirit-Levelling Operations in Madras Presidency	1	1 = 16	Corrected. Drawn on double the scale for reduction to one-half for Pamphlet No. 6, Madras Presidency Final press order given.
Final Reduction Chart, South West Quadrilateral	1	1 = 12	For reduction to one-half scale for Professional Volume. Final press order given.
Miscellaneous Maps.			
Diagram of N. E. Quadrilateral showing Assam Valley	1	...	For Synoptical Volume. Preliminary issue. Final press order given.
Diagram of the Southern Trigon.	1	...	For Professional Volume. Final press order given.
Map of Karwar Port	1	1 = ½	Ditto ditto ditto.
Diagram showing Tidal Curves at Karwar	1	...	Ditto ditto ditto.
Nepal Boundary Survey, Sheets Nos. 1, 2, 3 and 4 (Mechi River)	4	4 = 1	Corrected for reprints.
Forms—Professional	12	...	Prepared and final press order given.
Charts.			
Hazara Branch Series, by Lieutenant Robinson	1	1 = 4	Prepared tracings for Captain Wahab, R.E.
Triangulation of Hazara Field Force, 1888	1	1 = 4	
Final Triangulation, Mangalore Meridional Series	2	1 = 4	For reduction to one-half, for Synoptical Volume. Final press order given.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

DRAWING SECTION.

Statement showing work performed during the year 1890-91—continued.

Title.	Number of Sheets.	Scale.	Remarks.
Charts—contd.		In. M.	
Final Triangulation, Madras Longitudinal Series, South-East Coast Series, Madras Meridional and Coast Series, Great Arc Meridional Series, Section 8° to 18°, and Bombay Longitudinal Series	13	1 = ½&4	For reduction to one-half, for Synoptical Volume. In hand.
Triangulation, Khánpisura Meridional Series	2	1 = 4	Rough Charts, for use of the Computing office. Final press order given.
Triangulation, Burma Coast (for fixing of Beacons for the Marine Survey), Nos. 56, 57 and 58	3	1 = 2	Preliminary charts; corrections made. Final press order given.
Triangulation, Mandalay Merl. Series, Season 1889-90	1	1 = 4	Ditto ditto ditto.
Level Sheets Nos. 1 (3rd Edition), 67, 74, 88, 89 and 97	6	1 = 2	In hand.
Maps coloured	3,740	...	

Maps examined.

	Number of Sheets.
General maps	4
District maps (portions of)	10
Original standard maps	29
Trans-Frontier maps	5
Index maps	4
Miscellaneous maps	6
Tracing of original maps	11
Charts	21
Photo-zincographic proofs of standard sheets and various other maps	238
TOTAL	318

N.B.—In addition to the above, much miscellaneous work has been done, such as assisting in Photographic office; completing for press original maps of Central Provinces survey, Punjab survey and forest survey in respect to headings, foot-notes, etc.; putting in boundaries of districts on charts for use of the Computing office; supplying tracings of margins of Gujarat sheets to Gujarat Party; pantographing and transliterating three Russian maps for office use, and preparing a specimen of hill-shading for examination purposes.

Statement of work done for other Departments, etc., during the year 1890-91.

Title.	Number of Sheets.	Scale.	Remarks.
		In. M.	
General Maps.			
Map showing concentration of troops in Manipur in April 1891	1	1 = 16	Additions and corrections made to Map of Assam Province, for Quarter Master General. In press.
Standard Maps.			
Forest Surveys	38	Various	Completed headings and foot-notes, references, etc., and final press order given, for Forest Survey Branch.
North-Eastern Trans-Frontier, Sheet No. 21	2	1 = 8	Inserted points for Quarter Master General.
Miscellaneous.			
Colonel Tremenheere's Levels in Sind	1	1 = 4	Prepared a tracing for Director, Geological Survey of India.
Jaunsar Bawar Survey	7	1 = 2	Examined the tracings for Deputy Commissioner, Simla.
Maps coloured	485	Various.	

G. T. C. P. O.—No. 21 S. G.—11-4-92.—450.

1892. File No. 109.

GOVERNMENT OF INDIA. SERIAL No. 2.

REVENUE AND AGRICULTURAL DEPARTMENT.

SURVEYS.

RESOLUTION.

No. $\frac{1156\text{-}69}{109}$.

Dated Simla, the 11th June 1892.

SUBJECT.

Review of the General Report on the operations of the Survey of India Department for 1890-91.

G. C. Press, Simla.—No. 262 R. & A. D.—17-6-92.—715.

No.

Extract from the Proceedings of the Government of India in the Revenue and Agricultural Department,—No. $\frac{1156\text{-}69}{109}$ *(Surveys), dated Simla, the 11th June 1892.*

Read—

The General Report on the Operations of the Survey of India Department for the year 1890-91.

RESOLUTION.

The Report for 1890-91 has been brought out with commendable punctuality, is illustrated by excellent maps and photographs, and is well compiled.

2. Twenty-three parties and seven detachments were employed during the year on the various operations indicated in the following list:—

Nature of Survey.	No. of parties.	No. of detachments.
1. Trigonometrical	1	...
2. Topographical	4	1
3. Forest	4	...
4. Cadastral	7	1
5. Traverse	2	...
6. Scientific	3	...
7. Geographical	2	5

The surveys under the 3rd, 4th, and 5th heads of the list were of a remunerative character calculated to lead to the enhancement of land or forest revenue. Thus thirteen out of the twenty-three parties were engaged on revenue producing work.

3. The strain which had been thrown on the Department by the unexpected loss of officers, the annexation of Upper Burma, and other causes, was noticed in the Resolution on last year's report. During the year the Department was brought by recruitment up to its full strength, but the strain on it has lightened very little, and the Government of India are pleased to acknowledge the satisfactory manner in which the officers of the Department have endeavoured to fulfil the programme which has been placed before them.

4. It is unnecessary that any detailed account of the work done in each branch of the survey should be recorded in this Resolution, in which reference need only be made to the summary of the operations contained in the Surveyor General's review. One point, however, which deserves special mention is the satisfactory reduction of the cost rates shown in the tables on pages 82-85 as compared with the rates which prevailed a few years ago. This remark applies chiefly to the cost of cadastral surveys. The reduction is mainly due to the conscientious efforts of the officers of the Department to carry out the two principles of utilising local agencies and of expanding the subordinate staff under each controlling officer, and partly also to the increased experience gained in cadastral operations.

5. The opportunity may be usefully taken to draw attention to the canon laid down in the Imperial Resolution on survey administration, No. 45-S., dated 4th September 1882, that all field-surveys should be based upon a skeleton or framework prepared by the officials of the scientific department, and that details only should be filled in by locally trained agency. A tendency is often shown, when the Survey Department has started operations in a province, to permit continuance of them entirely by the local agency which has been initially trained by the survey

officials. This course may be successfully adopted for a short time, so long as the instructions of the survey officials are remembered; but sooner or later the accuracy of the traverse or skeleton survey prepared by new or inefficiently supervised workmen becomes impaired, and the maps are rendered more or less useless for inclusion in any cartographical series of recognized accuracy. The reduction of rates which has now been attained by the Survey Department has removed the objection of expense, which formerly stood in the way of the acceptance by some Provincial authorities of its aid in cadastral surveys, and the Government of India see no reason why any departure from the canon laid down should in future be justified. The matter is of great importance in connection with the maintenance of the topographical maps of the country, which can always be corrected at an insignificant cost if the cadastral maps maintained by local agency are based upon the same series of survey stations, but not otherwise. It becomes, therefore, the duty of the Surveyor General to bring to the notice of the Government of India any material breach of the canon laid down in 1882 in order that unnecessary expenditure may not be incurred in maintaining the cartographical series of maps in the Imperial office. His Excellency the Governor General in Council has, however, reason to be satisfied that at present the continuous efforts of the Department to reduce the acreage rates of all classes of survey are fully recognized by Provincial Governments, and that it is to this circumstance that the expansion of the programme which has been entrusted to the Survey Department, and which has resulted in the maintenance of the Imperial Survey establishments at a fuller strength than could at one time be anticipated, is greatly due.

6. The most important example of the now recognized utility of the Imperial Survey Department in provincial surveys is its present employment upon all cadastral and field-surveys in Bengal, in which province all such surveys had in previous times been executed by provincial establishments. It was essential that on this occasion the survey should be executed by the cheapest agency compatible with correct results. Colonel Sandeman, whose valuable work in bringing about the most economical amalgamation of scientific and local agencies that has as yet been effected was acknowledged by the Surveyor General and the Government of India in connection with the report for 1889-90, has been selected to take charge of all cadastral surveys in Bengal—a work which, in view of the forthcoming field-survey of Behar, is of no little magnitude. It is creditable to the Imperial Survey Department that this result has been secured by the persistent endeavours of its officers to reduce the acreage cost of survey to rates which justified the Provincial Government in accepting their control over the local surveys.

7. The same position has been obtained in Burma. There, however, the local officers were at first less capable of being utilized than in Bengal or Northern India, and the cadastral surveys had perforce to be conducted entirely by professional agency. It is satisfactory that during the last year material progress has been made in training Burman surveyors, and that a prospect is now held out of a gradual reduction in cadastral rates. Care, however, will have to be taken that the new local agency is not made too independent of the professional department, and that ultimate expenditure is not caused by a neglect of the canon to which reference has been made in paragraph 5. The same caution must be applied also to Assam.

8. The relations between the survey officials and the Provincial Governments have throughout the year been on a satisfactory footing, and the Government of India are glad to observe that the more frequent tours of the inspecting officers have tended to secure the result, which was anticipated, of removing such local difficulties as had hindered progress in consequence of insufficient personal communication between the Provincial authorities and the responsible officers of the Survey Department. The establishment of a thorough understanding between the Imperial Survey Department and the authorities in the Province where it is at work has, under the present system of financial decentralization, become one of the most important duties of the more responsible officers of the Department. No effort should be spared to secure this result.

9. The outturn of work has increased in every branch of the head-quarters offices, and it is satisfactory to notice that the demand for maps is steadily increasing. The total number issued in 1890-91 was 208,848, valued at Rs. 1,45,245. This number is four times greater than it was ten years ago. The Mathematical Instrument Department also did good work during the year. The value of the instruments issued amounted to Rs. 2,88,337, or Rs. 17,879 more than in the previous year.

10. The demands from the public for heliogravures are increasing, and the introduction of the photo-block process in half tones is satisfactory. The success with which Colonel Waterhouse has kept the photo-lithographic printing of the Department abreast with, and in some directions ahead of, European improvements is a subject for congratulation.

11. At the Dehra Office material progress has been made towards the reduction and publication of the trigonometrical records of past years, a work which it is important to bring to an early close in view of the Dehra buildings being required for other imperial purposes. Solar photography, which was started in 1877 at the request of the Industry, Science and Art Department, has been continued as usual, photographs of the sun having been taken throughout the year on all days that the sun was visible, and the negatives sent to the Solar Physics Committee at South Kensington. The results are included in the yearly volumes of Greenwich observations. But it is probable that a new observatory for the purpose of heliographic observations will be shortly established under a clearer atmosphere in the Madras Presidency, and the Dehra series will then cease.

12. The Department has been maintained in an efficient manner throughout the year, and the Government of India acknowledge the services rendered by the Surveyor General and the other officers of the Department.

ORDER.—Ordered, that the above Resolution be forwarded to the Surveyor General of India, to the Inspector General of Forests, to the Local Governments and Administrations noted on the margin, and to the Foreign, Military, and Public Works Departments.

Madras.	Punjab.
Bombay.	Central Provinces.
Bengal.	Burma.
North-Western Provinces and Oudh.	Assam.
	Coorg.

Ordered also, that the Resolution be published in the Supplement to the *Gazette of India*.

[True Extract.]

E. C. BUCK,

Secretary to the Government of India.

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Government of Maharashtra

on 01 February, 2020